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study on potential use of

industrialized building

for the department of the army

STUDY ON THE POTENTIAL USE OF INDUSTRIALIZED BUILDING FOR THE DEPARTMENT OF THE ARMY

VOLUME III: APPENDICES

By

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GLOSSARY

BUILDING: 1. the planning, designing and constructing of structures to house specified activities; 2. a structure so planned, designed and constructed.

INDUSTRIALIZED BUILDING: 1. building accomplished primarily in the manner of an industrialized process; 2. a structure built in this way.

BUILDING SYSTEM: A scheme for building which is distinguished by the fact that certain characteristics of the process and the product remain essentially unchanged for each new building constructed.

INDUSTRIALIZED BUILDING SYSTEM: the services and products required in a building system utilizing industrialized building.

BUILDING TYPE: A category of buildings constructed to house a specific activity or set of activities.

BUILDING PROJECT: any collection of the building types planned for construction during fiscal years 1973 through 1977.

MODULAR BUILDING: 1. a building system or partial building system characterized by the fact that its buildings are composed of prefabricated, box-like units which are connected together to form the building; 2. building to dimensional standards.

HARDWARE: the parts, components, assemblies and subsystems of which a building is constructed.

SOFTWARE: the rules and procedures for utilizing the hardware to form a completed building.

PRE-ENGINEERED BUILDING: 1. a building designed to satisfy a standard set of engineering requirements instead of the requirements of a particular customer; 2. a gable roof, clear span, metal building.

PREFABRICATED BUILDING: 1. a collection of fabricated parts from which a building can be assembled; 2. the building assembled from such parts.

PREASSEMBLED BUILDING: a completed building, except for the foundation, delivered to the site ready for attachment to the foundation and utilities.

OPEN BUILDING SYSTEM: 1. a building system permitting ready interchangeability of various components, assemblies and subsystems available on the open market; 2. a building system not having the areas of planning, designing and constructing under a single management control.

CLOSED BUILDING SYSTEM: 1. a building system having a fixed combination of components, assemblies and subsystems; 2. a building system having the areas of planning, designing and constructing under a single management control.

PROPRIETARY BUILDING SYSTEM: a building system or partial building system procurable only from a single source.

PARTIAL BUILDING SYSTEM: 1. a building system which addresses only a portion of a building; 2. a building system which does not address all three areas: planning, designing and constructing.

SUBSYSTEM: the building process may be thought of as constructing larger parts from smaller parts, then still larger parts from these parts and continuing this procedure until the building is complete; a building subsystem is any one of the larger parts, e.g., the structural subsystem.

ASSEMBLY: any one of the collection of parts from which a subsystem is constructed, e.g., a wall panel assembly (see subsystem).

COMPONENT: any one of the collection of parts from which an assembly is constructed, e.g., a window component (see assembly).

CONVENTIONAL BUILDING: 1. building accomplished primarily in the manner of a craft process; 2. a structure built in this way.

SYSTEMS BUILDING: the designing or selecting of a building system and the using of it to construct a building project.

SYSTEMS APPROACH: A strategy for applying systems building which considers building to be divisible into a set of interrelated elements that can be individually shaped and then connected together to provide the best building system for a given purpose within existing constraints.

APPENDIX A

DOD AND RECOMMENDED CONSTRUCTION CRITERIA

CONTENTS

PERFORMANCE STANDARDS FOR THE EVALUATION OF INDUSTRIALIZED BUILDING SYSTEMS FOR THE DEPARTMENT OF THE ARMY

PART I: INTRODUCTION

Purpose

The purpose of this report, as a contributory part of a more extensive study, was to determine the feasibility of employing industrialized building systems, subsystems and components for the construction of certain building types frequently required for U. S. Army use, as follow:

1. Administrative Buildings (ADM)
2. Bachelor Officer Quarters (BOQ)
3. Enlisted Men's Barracks (EMB)
4. Installation Storage Facilities (STO)
5. Classroom-Type Training Facilities (CLR)
6. Tank and Automotive Maintenance Facilities (TAM)

Objective

The objective of this report was to provide CERL with a means to evaluate the ability of available systems, subsystems or components to meet or exceed the performance standards currently governing the procurement of the building types listed; and in addition, a means to identify and evaluate levels of performance which should be expected of industrialized building systems producers.

Methods and Procedures

The specific methods and procedures utilized in producing this report were addressed to the following basic objectives:

1. to identify the principal subsystems which may be required for the construction of the listed building types, utilizing currently-available industrialized building products or techniques;

2. to subdivide these principal subsystems into elements and characteristics which require evaluation to determine acceptability;

3. to identify elements and characteristics presently governed by the Department of Defense Manual of Construction Criteria, DOD No. 4270.1-M, March 1, 1968 Edition, (hereinafter termed "DOD"), and to identify its requirements, when available, theretore;

4. to develop and recommend performance standards for each of the elements and characteristics, such standards based upon one or more of the following:

a) requirements of DOD;

b) requirements of nationally-recognized code authorities, trade associations and professional societies;

c) results of similar private and public studies, conducted for similar purposes for similar building types;

d) minimum standards for Federally-financed housing;

e) current technological and production capability of private industry; and

f) professional judgment by the authors of this Report.

5. and, to identify applicability of performance standards to each of the listed building types.

Assumptions

The development of "Recommended" performance standards assumed, for purposes of this study, the following:

1. design and planning criteria, such as size, modularity, functional relationships, aesthetics and the like were intentionally excluded, although such criteria are necessary for optimum utilization of industrialized building systems;

2. that the military building projects contemplated in this study are not governed by local or state codes, building or zoning authorities or insurance rating bureaus;

3. that the listed building types will not exceed three stories in height, nor be influenced by adjacency to hazardous or other special occupancies;

4. that these performance standards will be for the purpose of evaluating the current state-of-the-art in industry, and will not represent performance specifications to govern proposals in response to a comprehensive procurement program; and

5. that industrialized building systems, subsystems and components will not necessarily be procured or constructed through currently-authorized methods.

PART II: PERFORMANCE STANDARDS

Explanation of Format

To preserve maximum page area for technical content, headings are condensed on each of the Performance Standard Tables following in this Part II; more detailed explanation of their format is as follows:

1. the major heading identifies the principal "Subsystem: ------------";

2. "Elements/Characteristics" includes numbered sub-headings and unnumbered sub-headings to further subdivide the subjects analyzed;

3. "Current DOD Criteria" lists available excerpts related to listings under "Elements/ Characteristics" column; in many cases DOD Criteria are necessarily excerpted in the descriptive terms as expressed in the DOD Manual; the absence of entries in this column signifies no DOD criteria available;

4. "Recommended Standards" include performance standards related to listings under "Elements/Characteristics" column, derived as set forth under "Methods and Procedures" in Part I of this report; insofar as practicable, these standards are expressed in measurable terms;

5. Application to Building Types: a mark in one or more of the six columns at the right-hand edge of the Tables signifies that the "Recommended Standard" is pertinent to the Building type(s); the absence of a mark means "not normally applicable" or "not recommended"; abbreviations in column headings are defined as follow:

a) "ADM": Administrative Buildings

b) "BOQ": Bachelor Officer Quarters

c) "EMB": Enlisted Men's Barracks

d) "STO": Installation Storage Facilities

e) "CLR": Classroom-type Training Facilities

f) "TAM": Tank and Automotive Maintenance Facilities

6. references to test methods, recognized standards and the like are indicated by parenthetic numerals, e.g. (13) in the Tables; abbreviations which may appear in the Tables are as follow:

ACI	American Concrete Institute
AGA	American Gas Association
AIA	American Institute of Architects
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BOCA	Building Officials Conference of America
CS	Commercial Standard
FS	Federal Specification
FTMS	Federal Test Method Standard
HUD	Department of Housing and Urban Development
IEEE	Institute of Electrical and Electronic Engineers
IES	Illuminating Engineers Society
ISO	International Standards Organization
NAAMM	National Association of Architectural Metal Manufacturers
NBC	National Building Code
NBS	National Bureau of Standards
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NPC	National Plumbing Code
UBC	Uniform Building Code
UL	Underwriters' Laboratories, Inc.

SUBSYSTEM: 1.0 STRUCTURE								
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMR	STO	CLR	TAM
1.1 Static Loads Dead Loads	Floors shall be designed to support all dead loads safely.	All structural elements shall be designed to safely support all dead loads, permanent or temporary, including self-weight, roofing, insulation, ceilings, floor covering and mechanical equipment.	X	X	X	X	X	X
Live Loads-Roof	15 to 40 PSF per DOD(1)* *parenthetical numerals indicate references	20 PSF minimum, to 40 PSF per DOD(1). Application of design snow load shall be per AISC(2).	X	X	X	X	X	X

SUBSYSTEM: 1.0 STRUCTURE			ADM	BOO	EMB	STO	CLR	TAM
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS						
Live Loads - Floor:	In general per DOD(1); specifically:	Per DOD(1) except as follows:	X	X	X	X	X	X
elec. data process	150 PSF	Per mfr.'s recommendation	X					
computer room	200	Per mfr.'s recommendation	X					
private office	50		X				X	
clerical office	80		X				X	
letter file room	80		X				X	
card file room	125		X					
main office corr.	100	All corridors same live load as major contiguous area served	X				X	
secondary off. corr.	60		X				X	
school corridor	100						X	
residential corr.	60							
residential dwelling areas	40			X	X			
main toilet/shower room	60							
ext. balcony	100			X	X			
stairway	100							
classroom	40							
light warehouse	125		X		X		X	
heavy warehouse	250			X	X			
loading platform	250		X	X	X	X	X	X
3-10T truck gar.	150						X	
greater than 10 T truck gar.	200				X			
						X		X
						X		X
								X
								X

SUBSYSTEM: 1.0 STRUCTURE			ADM	DOQ	EMB	STO	CLR	TAM
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS						
Live Loads - Floor: partition allowances	20 PSF (residential)	When locations are permanent, add actual weight. When subject to relocation: when Live Load is 50 PSF or less, add actual weight of partitions contemplated, converted to PSF of floor area, but not less than 10 PSF. when Live Load is greater than 50 PSF but less than 80 PSF, add actual weight of partitions contemplated, converted to PSF of floor area. when Live Load is 80 PSF or greater no allowance required provided actual weight of partitions contemplated does not impose more than 20 PSF of floor area.	X	X	X	X	X	X
Live Loads-Concentrated: floors	2000 lbs. on area 2.5 ft. square in main corridors, large offices and similar areas per DOD(1).	Same as DOD(1) except applicable to all floor areas	X			X	X	X

SUBSYSTEM: 1.0 STRUCTURE			ADM	BOQ	EMB	STO	CLR	TAM
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS						
wheel loads	150% maximum wheel load anywhere on garage floor per DOD(1).	Same as DOD(1)				X		X
stairway & balcony		Per NBC(3)	X	X	X	X	X	X
stairway & balcony railings	50 plf lateral thrust applied to top of railing per DOD(1).	Same as DOD(1)	X	X	X	X	X	X
Live Load Reduction	Permitted per DOD(1)	Same as DOD(1)	X	X	X	X	X	X
Wind Load:	Per DOD(1)	Same as DOD(1)	X	X	X	X	X	X
velocity distribution		per ASCE(4)	X	X	X	X	X	X
1.2 Dynamic Loads	Per DOD (5)	Same as DOD(5)	X	X	X	X	X	X
Hurricane-Typhoon Vibration		design per AISC(6); see also Reference (7).	X	X	X		X	
Seismic	Per DOD(8)	Per DOD(8) as supplemented by ACI (9) (10).	X	X	X	X	X	X
Impact	Live loads include allowance for ordinary impact conditions	Per NBC(11); in addition increase live load on crane support members by 25%.	X	X	X	X	X	X

SUBSYSTEM: 1.0 STRUCTURE

ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
1.3 Deflection Vertical: with ceiling		$\frac{L}{360}$ or 2" maximum under live load	X	X	X	X	X	X
without ceiling		$\frac{L}{240}$ under live load				X		X
Horizontal: total buildings		K x H' where K = .0025 unfactored wind loads = .0050 unfactored static seismic loads H' = building height	X	X	X	X	X	X
walls		K x H where: K = .0025 unfactored wind loads = .0050 unfactored static seismic loads H = floor-floor height	X	X	X	X	X	X
Camber		All floor and roof members shall be cambered to eliminate deflection arising from dead load to the extent required to assure correct interface with other Subsystems herein including calculated time-based deflection due to specific material properties.	X	X	X	X	X	X

SUBSYSTEM: 1.0 STRUCTURE

ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
1.4 Fire Protection Fire Resistive: framing flr-clg	 2 hr. 2 hr.	Fire-Resistive, Type B per NBC	X	X	X	X	X	X
Prot. Non-Comb: framing flr-clg	 1 hr. 1 hr.	Protected Non-Combustible per NBC	X	X	X	X	X	X
Unprot. Non-Comb: framing flr-clg	 non-comb. non-comb.	Unprotected Non-Combustible per NBC	X	X	X	X	X	X
Heavy Timber		Heavy Timber per NBC				X		X
Ordinary: framing flr-clg	 none 1/2 hr.	Ordinary per NBC		X	X			
Wood Frame: framing flr-clg	 none none	Wood Frame per NBC		X	X			
		hourly rating for NBC Construction Classifications above shall meet Fire Resistance Classifications per UL, or tests in accord with ASTM E 119.						

SUBSYSTEM: 1.0 STRUCTURE

ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
1.5 Acoustics Structure-borne Noise		Design structural elements to implement noise control standards set forth in other Subsystems herein (12).	X	X	X		X	
1.6 Compatibility General		All structural elements shall be designed to support and interface with, when required, other Subsystems herein.	X	X	X	X	X	X
Dimensional Tolerance Horizontal: members location total module		±1/2" ±1/2" in 20'; ±3/4" in 40' ±1"	X	X	X	X	X	X
Dimensional Tolerance Vertical: members location total story height		±1/4" ±1/2" in 20'; ±3/4" in 40' ±1/4" in 10'; ±3/8" in 20'	X	X	X	X	X	X

SUBSYSTEM: 1.0 STRUCTURE			ADM	BOQ	EMB	STO	CLR	TAM
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS						
1.7 Material Properties Characteristics	Each material to be used structurally shall be of known uniform quality and physical characteristics. Selection and uses shall be determined with full consideration for the range of possible loads and forces which may be imposed on the design by wind and snow, seismic and explosive disturbances and vibration and impact - producing equipment.	Same as DOD	X	X	X	X	X	X
Volume Change		When structural elements are subjected to change in volume and/or shape due to shrinkage, creep, temperature changes, temperature gradients or changes in moisture content, the structural Subsystem shall resist all forces resulting from the most severe changes contemplated during the life of the structure, together with the most adverse combination of design loads, without local damage resulting from (a) (continued)	X	X	X	X	X	X

SUBSYSTEM: 1.0 STRUCTURE

ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
		(a) delamination, spalling or other local damage, (b) damage to Structure Subsystem, and (c) damage to any other Subsystem herein.						
Deterioration Resistance: corrosion, decay, spalling, leaching, delamination		Design Structure Subsystem to (a) eliminate continuous voids between sources at moisture-laden air and structural surfaces which can be at a temperature below dew point, (b) provide vapor barriers, ventilation or other means to prevent passage of water vapor from warm, moisture-laden areas to concealed structural surfaces subject to condensation, and (c) resist reduction in strength, during the anticipated life of the structure, due to exposure to climatic conditions normal to the site.	X	X	X	X	X	X

SUBSYSTEM: 1.0 STRUCTURE			ADM	BOQ	EME	STO	CLR	TAM
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS						
1.8 Spatial Characteristics Bay Size	25 X 40 feet recommended most economical for steel and concrete	30 X 50 feet for optimum cost for steel; 30 X 30 feet for optimum cost for concrete or timber				X		X
Story Heights: administration barracks and dormitories bach. off. qtrs.	 not over 11 feet 9.5 to 10.5 feet not over 10 feet	As required to produce clear ceiling heights as set forth in the functional program for the facility	X	X	X		X	
Clear Height	12 to 19.5 feet clear	Same as DOD or as set forth in the functional program for the facility.				X		X
Penetration		Design to permit penetration, horizontal and vertical, by electro-mechanical services required by other Subsystems herein.	X	X	X	X	X	X

SUBSYSTEM: 2.0 EXTERIOR WALLS

ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
2.1 General	Concrete masonry units, cast-in-place concrete, precast concrete, metal, prefabricated panels, brick when competitively bid or to match existing construction. Economic studies shall give consideration to load bearing masonry walls whenever practicable.		X	X	X	X	X	X
2.2 Strength Lateral Loads	Wind loads per DOD(1)	Same as DOD(1); tested per NAAMM TM-1-68T (13)	X	X	X	X	X	X
Impact		Per ASTM E72-68, Sections 12 and 13; tests conducted on full height panels; instantaneous deflection shall not exceed 1 inch nor permanent set of 1/16 inch after 5 drops at various heights. Surface shall show no cracking or chipping when tested per MIL-T-1717a, paragraph 4.4.4.6.	X	X	X	X	X	X

SUBSYSTEM: 2.0 EXTERIOR WALLS			ADM	BOQ	EMB	STO	CLR	TAM
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS						
2.3 Fire Safety								
Load Bearing:								
prot. non-comb.	1 hr.	1 hr.	X	X	X	X	X	X
unprot. non-comb.	non-comb.	Non-comb.	X	X	X	X	X	X
heavy timber		2 hr.				X		X
ordinary	1 hr.	1 hr.		X	X			
wood frame	1/2 hr.	1/2 hr.		X	X			
Non-Load Bearing:								
prot. non-comb.	non-comb.	Non-comb.	X	X	X	X	X	X
unprot. non-comb.	non-comb.	Non-comb.	X	X	X	X	X	X
heavy timber		0 (30' separation)				X		X
ordinary	non-comb.	Non-comb.		X	X			
wood frame	wood	wood		X	X			
Insulation:								
fire rating	non-comb.	Non-comb.	X	X	X	X	X	X
flame spread	25 max.	25 max.	X	X	X	X	X	X
smoke generation	50 max.	50 max.	X	X	X	X	X	X
		Ratings for walls and insultation above shall meet Fire Resistive Classification per UL, or tested in accordance with ASTM E 119-67.						
Flame Spread		Flame spread rating of exterior surface shall not exceed 200 when tested in accord with ASTM-E84-67; for interior surface flame spread see Subsystem 5.0 Interior Partitions herein.	X	X	X	X	X	X

SUBSYSTEM: 2.0 EXTERIOR WALLS			ADM	BOQ	EMB	STO	CLR	TAM
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS						
Smoke Generation		Maximum specific optical density of smoke generated by exterior surface shall not exceed 450 (flaming test only) when tested in accord with ASTM STP 442, (14); for interior surface smoke generation see Subsystem: 5.0 Interior Partitions herein.	X	X	X	X	X	X
Potential Heat		The limit of combustibility for any square foot of exterior wall section classed non-combustible, excluding wall finishes, shall not exceed 8000 BTU when tested in accord with ASTM Proceedings 61 (15).	X	X	X	X	X	X
2.4 Finish Properties Interior		For interior finish properties see Subsystem: 5.0 Interior Partitions herein.	X	X	X	X	X	X
Exterior color	Federal Std. No. 595	Federal Std. No. 595 No restriction except texture shall not adversely affect compliance with other Properties Standards required herein.	X	X	X	X	X	X
texture			X	X	X	X	X	X

SUBSYSTEM: 2.0 EXTERIOR WALLS			ADM	BOQ	EMB	STO	CLR	TAM
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS						
Weathering		Exposure to weathering elements shall not impair basic wall resistance to loads or water and air infiltration, nor deteriorate the wall to such an extent as to prohibit meeting Properties Standards as required herein.	X	X	X	X	X	X
Moisture		14 day exposure per Method 6201 of FTMS 141a shall result in no change in adhesion or resistance to abrasion or scratch of surface when tested as follows: Adhesion: Method 6303.1 FTMS 141a Abrasion: Method 4421 FTMS 141a Scratch: Method 7711 FTMS 501a	X	X	X	X	X	X
Water and Light		No surface change after 2000 hr. exposure per Method 6152 of FTMS 141a.	X	X	X	X	X	X
Corrosion		No corrosion after 7 days exposure per Method 6061 of FTMS 141a (salt spray or fog test).	X	X	X	X	X	X

SUBSYSTEM: 2.0 EXTERIOR WALLS			ADM	BOQ	EMB	STO	CLR	TAM
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS						
Chemical Resistance		Resist staining or damage from soluble and insoluble salts, alkali attack, corrosion, oxidation or other forms of attack from atmospheric conditions and normal care of surface.	X	X	X	X	X	X
Biological Resistance		Resist damage from insects, rodents, vermin, mildew, fungi, algae or other forms of attack from organisms.	X	X	X	X	X	X
2.5 Wall Properties Acoustics		For solid walls, with or without glazing, Sound Transmission Class (STC) shall be equal to or greater than 42;	X	X	X		X	
		for a 10' X 20' solid wall section with a door STC shall be equal to or greater than 37. See HUD manual (16); tested in accordance with ASTM E90-66.	X	X	X		X	

SUBSYSTEM: 2.0 EXTERIOR WALLS

ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
Thermal	In areas of 4000+ heating degree days, full consideration for insulating glass for window walls, picture windows and glazed doors shall be given; consider storm sash or insulated glass for personnel spaces in areas of $0^{o}F$ temperatures							
	Personnel Spaces @ $70^{o}F$: U = .17 @ $-40^{o}F$ to $-10^{o}F$ = .21 @ $-9^{o}F$ to $+10^{o}F$ = .27 @ $+11^{o}F$ to $+35^{o}F$ Installations/Maintenance: U = .27 @ $-40^{o}F$ to $-10^{o}F$ = .35 @ $-9^{o}F$ to $+35^{o}F$	Winter Heat Loss-Walls: including doors and excluding windows, winter heat loss shall not exceed 15 BTU/hr/sq.ft. of wall with a temperature differential of design outdoor temperature and $75^{o}F$ indoor temperature.	X	X	X	X	X	X
		Winter Heat Loss-Windows: under winter design conditions with $75^{o}F$ indoor temperature window heat loss shall not exceed 150% of the total allowable heat loss through non-window areas of the exterior walls.	X	X	X	X	X	X
		(continued)						

SUBSYSTEM: 2.0 EXTERIOR WALLS

ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
		If, for reasons of minimum natural light or essential architectural treatment, the heat loss in any one particular wall is above the limits set, it shall be compensated for in the heating system or window accessories.						
		Summer Heat Gain-Walls: under summer design dry bulb conditions and 75°F indoor temperature heat gain through walls shall not exceed 4 BTU/hr/sq.ft. of wall.	X	X	X		X	
		Summer Heat Gain-Windows: the solar heat gain through windows shall not exceed a maximum average of 26 BTU/hr/sq.ft. of exposed wall and glazing in any orientation; glazed areas shall be limited and/or shielded to maintain this value.	X	X	X		X	

SUBSYSTEM: 2.0 EXTERIOR WALLS

ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
Vapor Penetration		Provide a vapor barrier having a permeance of less than or equal to 1 perm on the winter warm side of the wall when the wall "U" factor is less than or equal to .25 or if the permeance of the outside (cold) surface is less than 5 perms; tested in accord with ASTM Dry Cup Test Procedure "A," E96-66.	X	X	X	X	X	X
Moisture Penetration		Exclude all water at doors, windows and walls; in order to neutralize pressure differential which draws moisture through wall, provide an air chamber sealed on the building side and ventilated to the outside air between the insulation and the outside wall material.	X	X	X	X	Y	X
		Walls tested per NAAMM Std. TM-1-68T(13) or ASTM E331-68. Windows tested per NAAMM Std. SW-1-77(18) or ASTM E 331-68						

SUBSYSTEM: 2.0 EXTERIOR WALLS

ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
Air Infiltration		Maximum air infiltration for fixed wall shall not exceed 0.06 CFM/sq.ft. of exposed wall and for operable windows shall not exceed 0.05 CFM/lin.ft. of operable sash perimeter. Walls tested per NAAMM Std. Tm-1-68T(13) or ASTM E283 Windows tested per NAAMM Std. SW-1-71(18) or ASTM E283	X	X	X	X	X	X
Condensation		Thermal breaks shall be provided in highly conductive materials used in the construction of wall panels, doors, and windows where cold spots would contribute to the formation of condensation.	X	X	X	X	X	X
Volume Changes		Thermal movement due to ambient temperature range of 120°F shall be compensated for in design and fabrication of joints to permit expansion and contraction of components without impairment of performance against air and water leakage or objectionable buckling.	X	X	X	X	X	X

SUBSYSTEM: 2.0 EXTERIOR WALLS								
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
2.6 Natural Light and Ventilation								
General	fixed windows are permitted for totally air conditioned situations only; all other windows shall be operable sash	Same as DOD	X	X	X	X	X	X
Personnel Spaces		Same as DOD	X	X	X		X	
min. glass	10%							
min. ventilation	5%							
max. glass @ $0^{o}F$	15%							
max. distance to window	25′							
Maintenance Facilities		Same as DOD						X
min. glass	12.5%							
min. ventilation	6.25%							
max. glass @ $0^{o}F$	15%							
Warehouses	no requirement	Same as DOD				X		
Bathrooms	the above does not preclude location away from exterior walls, if positive Mech. Ventilation is provided.	Same as DOD	X	X	X	X	X	X
2.7 Compatibility								
General		Exterior Wall Subsystem shall be designed to interface with other Subsystems herein.	X	X	X	X	X	X

SUBSYSTEM: 2.0 EXTERIOR WALLS

ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
Penetration		Subsystem shall be capable of accommodating passage of electro-mechanical branch services to other Subsystems herein, vertically and horizontally, either within the wall thickness or within cavities formed of similar components.	X	X	X	X	X	X

SUBSYSTEM: 3.0 ROOF/CEILING								
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
3.1 General		Refer to Subsystem: 4.0 Floor/Ceiling for ceiling Standards also applicable to this Subsystem with regard to Strength, Finish Properties, Acoustics and Integrated Lighting/Ceiling; otherwise, standards for Roof/Ceiling are stated herein.	X	X	X	X	X	X
3.2 Strength Live Loads: roof wind		Same as Subsystem: 1.0 Structure herein.	X	X	X	X	X	X
Dynamic Loads: hurricane-typhoon vibration seismic impact		Same as Subsystem: 1.0 Structure herein.	X	X	X	X	X	X
Concentrated Loads		Roof shall support 250 pounds on 4 sq. in. without puncture or failure of membrane or insulation.	X	X	X	X	X	X

SUBSYSTEM: 3.0 ROOF/CEILING			ADM	BOQ	EMB	STO	CLR	TAM
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS						
Penetration Resistance		Roof shall resist light foot traffic without adverse effect; and resist impact of 1-1/2 inch hail at 112 ft./sec. with no water entry when test-	X	X	X	X	X	X
3.3 Fire Safety Rating		Minimum 3/4 hr. when tested in accord with ASTM E119-67.	X	X	X	X	X	X
Flame Spread: roof		Flame spread rating of roofing surface shall be Class C or better when tested in accord with ASTM E108-58.	X	X	X	X	X	X
ceiling		Flame spread rating of ceiling surface shall not exceed 150 when tested in accord with ASTM E84-67.	X	X	X	X	X	X
Smoke Generation		Maximum specific optical density of smoke generated by ceiling surface shall not exceed 300 when tested in accord with ASTM STP 422 (14).	X	X	X	X	X	X

SUBSYSTEM: 3.0 ROOF/CEILING

ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
Potential Heat		The limit of combustibility for any square foot of roof/ceiling assembly (applied only to the structural part of the assembly and its fire protection) shall be 5,000 BTU when tested in accord with ASTM Proceeding 61 (15).	X	X	X	X	X	X
Roof Covering	Class A, B or C listed by UL, Factory Mutual Engineering Division or other recognized testing laboratory.	Same as DOD	X	X	X	X	X	X
Insulation: classification flame spread smoke developed	 non-combustible rating not higher than 25 rating not higher than 50	Same as DOD	X	X	X	X	X	X
3.4 Assembly Properties Acoustics: sound isolation		STC (Sound Transmission Class) shall be equal to or greater than AIA Chapter 13 (17) when tested in accord with ASTM E90-66.	X	X	X		X	

SUBSYSTEM: 3.0 ROOF/CEILING								
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
impact		IIC (Impact Insulation Class) values shall be equal to or better than FHA Criteria of Impact Noise Curve per AIA Chapter 13 (17), with INR (Impact Noise Reduction) of minus 5 for office and classroom areas, when tested in accord with ISO R140-1960(21).	X	X	X		X	
general		Refer to Chapters 6 and 7, HUD (16) (12).	X	X	X		X	
Heat Transmission:	calculated per ASHRAE methods: "U" = 0.07 max.	Same as DOD						
personnel - type facility heated to min. 70°F.			X	X	X		X	
shop areas of installation-maintenance, similar facility.	"U" = 0.10 max.							X
warehouse	U = .12 @ –40°F to –10°F = .18 @ – 9°F to +10°F = .25 @ +11 to +35°F					X		

SUBSYSTEM: 3.0 ROOF/CEILING			ADM	BOQ	EMB	STO	CLR	TAM
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS						
Water Resistance: general		Susceptible roof construction (e.g. gypsum) shall not be permanently damaged or rendered unsafe in the event of wet·ing from humidity or other cause and shall be capable of drying to the indoor air.	X	X	X	X	X	X
leakage		Membrane and flashings shall allow no water penetration for not less than 20 years.						
moisture		Provide vapor barrier with permeance not greater than 1/2 perm near the winter warm side of son-struction and provide ventilation of insulation to the outside air, to protect against moisture accumulation in insulation or at interface of membrane and deck.						
condensation		Provide thermal break in materials with high thermal conductance (e.g. metals) when used in construction where cold spots contribute to condensation.						

SUBSYSTEM: 3.0 ROOF/CEILING

ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
Weathering		Membrane and flashings shall not split, slip, wrinkle, buckle, blister, or erode due to adverse effects of temperature and moisture change, sunlight or atmosphere for not less than 20 years.	X	X	X	X	X	X
Volume Change		Thermal movement due to ambient temperatures shall be compensated for to permit expansion and contraction without impairment of performance against weather and moisture.	X	X	X	X	X	X
3.5 Compatibility General		Roof/Ceiling Subsystem shall be designed to interface with other Subsystems herein.	X	X	X	X	X	X
Penetration		Refer to Subsystem: 4.0 Floor/Ceiling for Penetration Standards also applicable to this Subsystem.	X	X	X	X	X	X

SUBSYSTEM: 4.0 FLOOR/CEILING

ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
4.1 General Ceilings	painted structure, plaster, gypsum board, acoustic tile; suspended where required for fire safety, passage of ducts, objectionable structure, or functional demands		X	X	X	X	X	X
Floors	based on a concrete structural floor . . . steel troweled concrete, vinyl asbestos tile, ceramic tile, quarry tile.		X	X	X	X	X	X
4.2 Strength Ceiling	resist reaction of partitions lateral load (10-15 PSF)	Same as DOD	X	X	X	X	X	X
Floor General		Floors shall support all loads including lateral reaction from interior partitions	X	X	X	X	X	X
Live Loads: floor wind		Same as Subsystem: 1.0 Structure herein.	X	X	X	X	X	X

SUBSYSTEM: 4.0 FLOOR/CEILING			ADM	BOQ	EMB	STO	CLR	TAM
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS						
			X	X	X	X	X	X
Dynamic Loads: hurricane-typhoon vibration seismic impace		Same as Subsystem: 1.0 Structure herein.	X	X	X		X	
Floor Surface: impace		Surface shall show no cracking or chipping when tested per MIL-T-1717a, Para. 4.4.4.6	X	X	X		X	
indentation		Floor surface shall resist permanent indentation from concentrated loads and residual indentation shall not exceed 0.10 inches when tested in accord with Method 3231 of FTMS 501a using a 50 lb. load for 7 days and a 24 hr. recovery period; also simulate design loading per ASTM D2394-68.						

SUBSYSTEM: 4.0 FLOOR/CEILING			ADM	BOQ	EMB	STO	CLR	TAM
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS						
4.3 Fire Safety Floor/Ceiling Assembly								
prot. non-comb.	1 hr.	1 hr.	X	X	X	X	X	X
unprot. non-comb.	non-comb.	non-comb.	X	X	X	X	X	X
heavy timber		no rating				X		X
ordinary	1/2 hr.	1/2 hr.		X	X			
wood frame	0 (no rating)	no rating		X	X			
		Hourly ratings for floor/ceiling assemblies above shall meet Fire Resistive Classifications per UL, or tests in accord with ASTM E 119.						
Flame Spread: ceiling		Flame Spread rating of ceiling surface shall not exceed 150	X	X	X	X	X	X
floor covering		Flame Spread rating of floor covering shall not exceed 200; tested in accord with ASTM E84-67.	X	X	X	X	X	X
Smoke Generation: ceiling		Maximum Specific optical density of smoke generated by ceiling shall not exceed 300	X	X	X	X	X	X

SUBSYSTEM: 4.0 FLOOR/CEILING								
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
floor covering		Maximum Specific optical density of smoke generated by floor covering shall not exceed 450; tested in accord with ASTM STP 422. (14)	X	X	X	X	X	X
Potential Heat		The limit of combustibility for any square foot of floor/ceiling assembly classed noncombustible, which applies only to the structural part of the assembly and its fire protection, shall be 5000 BTU when tested in accord with ASTM Proceedings 61. (15).	X	X	X	X	X	X
4.4 Finish Properties Color	F Federal Std. No. 595	Federal Std. No. 595	X	X	X	X	X	X
Texture Texture		No restriction except texture shall not adversely affect compliance with other Properties Standards required herein.	X	X	X	X	X	X
Glass		Floors and Ceilings shall be non-glossy to diffuse light and reduce glare.	X	X	X		X	

SUBSYSTEM: 4.0 FLOOR/CEILING								
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
Reflectance: ceilings		Ceilings and the nonluminous parts of integrated lighting/ceilings shall have a reflectance not less than 80%	X				X	
floors		Floors shall have a reflectance not less than 35%; measured with a Baumgartner type spherical reflectometer.	X				X	
Abrasion Resistance Floors: ceramic tile		Abrasion resistance shall be equal to or greater than Standards set for in ANSI A137.1-1967.	X	X	X		X	
floor tile		Abrasion resistance of all floor tile shall be equal to or greater than standards set forth in Fed. Spec. SS-T-312 Type IV for vinyl asbestos tile.	X	X	X		X	

SUBSYSTEM: 4.0 FLOOR/CEILING

ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOO	EMB	STO	CLR	TAM
carpet		Abrasion resistance shall be tested by 700,000 revs. in a Tetrapad Walker abrasion test and shall result in a rating of not less than 3 (Fair:Moderate abrasion).	X	X	X		X	
other surfaces		Other smooth surfaces shall abrade no more than 0-2.5 cc in a standard 60 cycle test with an Armstrong Abrader	X	X	X		X	
Stain Resistance Floors: ceramic tile		Stain resistance shall be equal to or greater than standards set forth in ANSI X137.1-1967.	X	X	X		X	
floor tile		Stain resistance of all floor tile shall be equal to or greater than standards set forth in Fed. Spec. SS-T-312 Type I for vinyl asbestos tile.	X	X	X		X	

SUBSYSTEM: 4.0 FLOOR CEILING

ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
carpet		Follow manufacturer's recommended procedures for stain removal; as a general guide to stain removal for carpets see Technical Bulletins T173 and T174 of the National Institute of Rug Cleaning (22).	X	X	X		X	
other surfaces		Stain resistance per ASTM D1308-58 "Effect of Household Chemicals on Floor Finishes."	X	X	X		X	
Aging-Floors		Floor surfaces shall maintain an acceptable level of performance for 10 years under light traffic add for 5 years under heavy traffic when tested in accord with Fed. Spec. SS-T-312a (gradual color mellowing is acceptable).	X	X	X		X	
Ultra-Violet Resistance Floors		Floor surfaces shall have no appreciable color change after 150 hours exposure at 150^{o}F in Atlas Fadeometer.	X	X	X		X	

SUBSYSTEM: 4.0 FLOOR/CEILING								
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
Moisture-Floors		Floor surfaces shall permit no water penetration when tested in accord with Para. 4.4.5 of Fed. Test Method TT-C-00555	X	X	X		X	
Humidity Resistance: group shower room, general laundry room, and similar wet areas		Floor/ceiling shall have no appreciable deterioration after 400 hrs. exposure to atmosphere with 100% humidity and 100°F temperature.		X	X			
other areas		Floor/ceiling shall have no appreciable deterioration after 100 hrs. of exposure to atmosphere of 100% humidity and 100°F temperature.	X	X	X		X	
Washability: floors		Normal care and maintenance shall not shrink, expand, soften, harden degrade, weaken, erode or otherwise alter the floor properties herein.	X	X	X		X	

SUBSYSTEM: 4.0 FLOOR/CEILING								
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
ceilings		No softening, color damage nor more than slight surface abrasion when tested with 15,000 brush strokes, wetted by 5% solution of trisodium phosphate in Gardner Straight Line Washability Machine.	X	X	X		X	
Biological		Floor and ceiling shall resist attact from fungi, mildew, bacteria, insects, rodents and other organisms.	X	X	X		X	
4.5 Acoustics Dwelling Areas		Sound Transmission Class (STC) and Impact Insulation Class (IIC) shall be equal to or greater than HUD Table 10-3, Grade II Criteria (20)		X	X			

SUBSYSTEM: 4.0 FLOOR/CEILING								
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
Other Occupied Areas		STC shall be equal to or greater than AIA Chapter 13 (17). IIC shall be equal to or greater than FHA Criteria Impact Noise Curve in AIA Chapter 13 (17) with impact Noise Rating (INR) equal to minus 5 for offices and classrooms STC tested in accord with ASTM E90-66; IIC tested in accord with ISO R140-1960. (21)	X				X	
Absorption-Ceiling		Noise Reduction Coef. shall be 0.50 to 0.70 at 500 CPS for ceiling when tested in accord with ASTM C423-66.	X				X	
4.6 Compatibility General		Floor/Ceiling Subsystem shall be designed to interface with other Subsystems herein.	X	X	X	X	X	X

SUBSYSTEM: 4.0 FLOOR/CEILING			ADM	BOQ	EMR	STO	CLR	TAM
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS						
Penetrations		Floor/Ceiling Subsystem shall be capable of accommodating passage of electro-mechanical services either within the floor structure or within a space defined between the structure and the ceiling level.	X	X	X	X	X	X
4.7 Integrated Lighting/Ceiling General	where illumination levels are greater than or equal to 100 fc, air conditioning and lighting shall be integrated.	Integrated lighting/ceiling is a special case of the Floor/Ceiling Subsystem. It shall meet all performance standards specified herein for Floor/Ceiling with regard to strength, fire safety, finish properties, acoustics and compatibility plus the additional requirements set forth hereinafter.	X				X	

SUBSYSTEM: 4.0 FLOOR/CEILING								
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
Additional Requirements: strength		Same as Floor/Ceiling plus support all fixture mountings and electro-mechanical terminals. See Subsystem: 8.0 Electrical for luminaire support.	X				X	
fire safety		Integrated Lighting/Ceiling shall be UL listed as part of a 1 hr. Fire Resistive Classification assembly with the floor, or tested in accord with ASTM E119.	X				X	
flame spread		Flame Spread rating of integrated lighting/ceiling surface shall not exceed 25 when tested in accord with ASTM E84-67.	X				X	
smoke generation		Same as Floor/Ceiling standard for ceiling surface.	X				X	
potential heat		Same as Floor/Ceiling	X				X	
acoustics		Same as Floor/Ceiling	X				X	

SUBSYSTEM: 4.0 FLOOR/CEILING

ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
Lighting		See Subsystem: 8.0 Electrical for lighting standards and references. Luminaries shall be integral with ceiling system, labeled by an approved agency, and shall conform to the inherent modularity of the integrated lighting/ceiling system.	X				X	
Electro-Mechanical		The integrated lighting/ceiling shall accommodate the requirements imposed by Subsystems 6.0: Plumbing, 7.0: HVAC and 8.0: Electrical for service outlets and terminals. These outlets and terminals shall be integral with the ceiling, labeled by an approved agency, and shall conform to the inherent modularity of the integrated lighting/ceiling system.	X				X	

SUBSYSTEM 4.? FLOOR/CEILING			ADM	BOQ	EMB	STO	CLR	TAM
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS						
Compatibility general		Same as Floor/Ceiling; in addition the integrated lighting/ceiling shall be a unified system of lighting elements and electro - mechanical outlets/terminals conforming to all standards of performance stated above and designed to interface with other Subsystems herein.	X				X	

SUBSYSTEM: 5.0 INTERIOR PARTITIONS								
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
5.1 General	Painted gypsum wall board			X				
	Glazed structural units		X	X	X	X	X	X
	Ceramic tile		X	X				
	Concrete masonry units		X	X	X	X	X	X
	Plaster			X				
52. Strength Lateral Load	10 PSF per DOD(1); 15 PSF :vhen design wind load greater th 40 PSF	Same as DOD(1)	X	X	X	X	X	X
Impact		Per ASTM E72-68 Sections 12 and ˙3; tests conducted on full-height ›artition and door not smaller than 3 X 7 feet; instantaneous deflection shall not exceed 1 inch nor permanent set of 1/16 inch after 5 drops of 2 feet. Surface shall show no cracking or chipping when tested per MIL-T-1717A, Para. 4.4.4.6.	X	X	X	X	X	X
Attachment Load	Support by bolts or through-bolts	Provide support for attachments equivalent to 40 PLF every 2 feet vertically on either or both sides of partition.	X	X	X		X	

SUBSYSTEM: 5.0 INTERIOR PARTITIONS

ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	HOM
5.2 Fire Safety								
Load Bearing:								
prot. non-comb.	1 hr.	1 hr.	X	X	X	X	X	X
unprot. non-comb.	non-comb.	non-comb.	X	X	X	X	X	X
heavy timber		2 hr.				X		X
ordinary	1 hr.	1 hr.		X	X			
wood frame	1/2 hr.	1/2 hr.		X	X			
Non-Load Bearing	non-comb.	non-comb.	X	X	X	X	X	X
Exit Corridor	1/2 hr. (door 1/2 hr.)	1/2 hr. (door 3/4 HR-C)	X	X	X	X	X	X
Stairway, mechanical	1 hr. (door 1 hr.)	1 hr. (door 1-1/2 HR-B)	X	X	X	X	X	X
Combustible Sto.	4 hrs. for storage of low/moderate combustibility From 20,000 to 40,000 sq. ft. (2 Class A doors)	same as DOD				X		
	2 hrs. for storage of low/moderate combustibility up to 20,000 sq. ft. (2 class A doors)	Same as DOD				X		
	4 hrs. for storage of hazardous combustibility up to 20,000 sq. ft. (2 Class A doors)	Same as DOD				X		
Fire Walls:								
unprot. non-comb.								
ordinary	2 hr. separating area over 9,000 sq. ft. (door 1-1/2 hr.)	Same as DOD	X	X	X	X	X	X
wood frame	2 hr. separating area over 5,000 sq. ft. (door 1-1/2 hr.)	Same as DOD	X	X	X	X	X	X

SUBSYSTEM: 5.0 INTERIOR PARTITIONS

ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
		Hourly ratings for partitions and doors under Section 5.3 herein shall meet Fire Resistance Classifications per UL, or tests in accord with ASTM E 119.						
Flame Spread		Flame spread rating of partition surface shall not exceed 75 when tested in accord with ASTM E84-67.	X	X	X	X	X	X
Smoke Generation		Maximum specific optical density of smoke generated by finished partition surface shall not exceed 150 when tested in accord with ASTM STP422. (14)	X	X	X	X	X	X
Potential Heat		The limit of combustibility for any square foot of partition section classed non-combustible, excluding surface finish, shall be 8000 BTU when tested in accord with ASTM Proceedings 61 (15).	X	X	X	X	X	X

SUBSYSTEM: 5.0 INTERIOR PARTITIONS			ADM	BOQ	EMB	STO	CLR	TAM
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS						
5.4 Finish Properties General	Finish and color of surrounding surfaces shall be selected to reduce glare, increase light utilization and obtain an acceptable brightness balance.		X	X	X	X	X	X
Color	Federal Std. No. 595	Federal Std. No. 595	X	X	X	X	X	X
Texture		No restriction except texture shall not adversely affect compliance with other Properties Standards required herein.	X	X	X	X	X	X
Gloss		Max. gloss rating not greater than 20 when measured by a 60-degree Gardner Gloss Meter.	X	X	X	X	X	X
Reflectance		40 to 60% when measured by Baumgartner reflectometer	X				X	
Abrasion Resistance: plastic laminate		Wear rate not to exceed 0.08 grams per 100 cycles, and the wear value shall be 200 cycles minimum for the laminates, when tested in accordance with NEMA LD1 - 201-1964, May 1957.	X	X	X		X	

SUBSYSTEM: 5.0 INTERIOR PARTITIONS								
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOO	EMB	STO	CLR	TAM
vinyl wall covering		No exposure of backing or base when tested in accord with Wyzenbach method, CCC-T-191B, Method 5304, 300 double rubs in circulation areas, 200 double rubs in other areas.	X	X	X		X	
all other finishes		Change in gloss not greater than 5%, measured on a Gardner 60-degree Gloss Meter, when tested using a Gardner Model 105 Washability and Abrasion machine, 150 cycles in circulation areas, 100 cycles in other areas.	X	X	X	X	X	X
Stain Resistance		No permanent discoloration or damage by application and removal 24 hrs. later of not more than three of the following: tea, coffee, household bleach, wet detergent, carbon tetrachloride, lipstick, cellulose tape, ballpoint ink, permanent ink	X	X	X		X	

SUBSYSTEM: 5.0 INTERIOR PARTITIONS								
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
Aging		No fading or rusting (slight dulling of surface permitted) after 900 hrs. exposure in National Carbon Co. X-1 Weathering Machine.	X	X	X		X	
Ultra-Violet Resistance		No appreciable color change after 150 hrs. exposure at approx. 150 degrees F. in Atlas Fadeometer.	X	X	X		X	
Humidity Resistance: group shower room, general laundry room and similar wet areas		No appreciable deterioration after exposure for 400 hrs. to atmosphere with 100% humidity and 100 degree F. temperature.		X	X			X
other areas		No appreciable deterioration after exposure for 100 hrs. to atmosphere with 100% humidity and 100 degree F. temperature	X	X	X		X	X
Washability		No softening, color change nor more than slight surface abrasion (including joints of laminated surfaces) when tested with brush wetted by 5% solution of trisodium phosphate in Gardner Straight Line Washability machine as follows:						

SUBSYSTEM: 5.0 INTERIOR PARTITIONS			ADM	BOQ	EMB	STO	CLR	TAM
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS						
circulation areas		100,000 brush strokes	X	X	X		X	
group shower and toilet rooms		50,000 brush strokes	X	X	X		X	X
other areas		15,000 brush strokes	X	X	X		X	X
5.5 Acoustics Sound Isolation: dwelling areas		Sound Transmission Class (STC) shall be equal to or greater than HUD Table 10.2, Grade II Criteria (20).		X	X			
other occupied areas		STC shall be equal to or greater than AIA Chapter 12 (17).	X	X	X	X	X	X
doors in partitions with required STC 48 or greater		Door shall be gasketed and STC not less than 29.	X	X	X	X	X	X
doors in partitions with required STC 32 to 48.		Door STC shall be not less than 24, gasketing optional.	X	X	X	X	X	X
doors in partitions with required STC less than 32.		No STC rating required.	X	X	X	X	X	X
		STC ratings hereinabove shall be when tested in accordance with ASTM E90-66.						

SUBSYSTEM: 5.0 INTERIOR PARTITIONS								
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
5.6 Compatibility General		Interior Partition Subsystem shall be designed to interface with other Subsystems herein.	X	X	X	X	X	X
Demountability		When required by the functional program for the facility, Subsystem shall be capable of being disassembled, relocated and re-erected without adverse effect on other Standards herein, and with 90% salvageability.	X				X	
Penetration		Subsystem shall be capable of accommodating passage of electromechanical branch services to other Subsystems herein, horizontally and vertically, either within the partition thickness or within cavities formed of similar components.	X	X	X		X	

SUBSYSTEM: 6.0 PLUMBING

ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
6.1 General Code	Plumbing and drainage shall comply with the American Standard National Plumbing Code A40.8 as issued by the ASME and, in general with the Report of the Coordinating Committee for a National Plumbing Code as issued jointly by the Housing and Home Finance Agency and the Department of Commerce.	Same as DOD, i.e., American Standard National Plumbing Code ASA A40.8-1955.	X	X	X	X	X	X
Fixture Allowance	Chapter 8, Article 8.7, Tables 8.6, 8.7, 8.7A and 8.10 provide fixture determination methods for Administrative Facilities, Bachelor Officer Quarters, Barracks and Dormitories and Installations--Maintenance Facilities.	Same as DOD, with Classroom-Type Training Facilities governed by Table 8.6.	X	X	X	X	X	X

SUBSYSTEM: 6.0 PLUMBING								
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
6.2 Structural Effect Deflection		This Subsystem shall accommodate deflections permitted in other Subsystems herein.	X	X	X	X	X	X
Loads		This Subsystem shall be unaffected by dead loads and service loads imposed on it and by it, including impact loads, static and dynamic fluid loads, temperature change and unrelieved installation stresses, as follows: no horizontal change in slope nor vertical direction change, from design directions, in excess of 1/8 inch/LF. no loss of stability or tightness sufficient to impair essential function or permit leakage. no adverse effects on other Subsystems herein.	X	X	X	X	X	X

SUBSYSTEM: 6.0 PLUMBING								
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
Support	Lavatories in central toilets in barracks shall be attached to and supported by hangers that are thru-bolted to the partition.	Function of plumbing fixtures and integrity of supports and attachments shall be unaffected when supporting a load of 300 pounds placed at mid-point of front rim and in center of sump.	X	X	X	X	X	X
6.3 Safety Fire		Elements of this Subsystem penetrating or contained within other Subsystems herein shall not impair the fire resistance Standards of those Subsystems.	X	X	X	X	X	X
Sprinklers	Chapter 10, subparagraphs10—1.1.1 and 10—1.2.1, provides for automatic sprinkler systems for certain facility types and conditions of occupancy or contents.	When required by the functional program for the facility, automatic sprinkler system shall meet the requirements of NFPA No. 13- 1969.	X			X	X	X

SUBSYSTEM: 6.0 PLUMBING			ADM	BOQ	EMB	STO	CLR	TAM
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS						
Freezing	Water and waste piping shall not be located in exterior walls or attic spaces where there is a danger of freezing.	Whenever subjected to freezing conditions of predictable frequency and duration, this Subsystem shall be insulated or otherwise protected from damage or impairment of essential function.	X	X	X	X	X	X
6.4 Fixtures Plumbing Fixtures (for land use)	Federal Specification WW-P-541b (for hospitals)	Same as DOD	X	X	X	X	X	X
Enameled cast iron		Commercial Std. 77-63	X	X	X	X	X	X
Staple Vitreous China		CS 20-63	X	X	X		X	
Earthware (vitreous glazed)		CS 111-43	X	X	X		X	
Formed metal Porc. enam. sanitary ware			X	X	X	X	X	X
		FS WW-P-54lb	X	X	X	X	X	X
Drinking Fountains		ANSI Z4.2-1942						
Gel-coated glass-				X	X			
fiber reinforced polyester resin:				X	X			
Bathtub units Shower stall units and receptors		ANSI Z124.1-1967 ANSI Z124.2-1967	X	X	X	X	X	X
Flush Valves	Lever-type, neoprene diaphragm, 39 inches above floor	Same as DOD						

SUBSYSTEM: 6.0 PLUMBING

ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
6.5 Acoustics Sound Isolation		This Subsystem shall neither compromise nor prevent attainment of the STC (Sound Transmission Class) Standards required for other Subsystems herein (12) (20) (17)	X	X	X	X	X	X
Noise Level		Noise level resulting from this Subsystem shall not exceed NC40 (20) (17).		X	X			

SUBSYSTEM: 6.0 PLUMBING

ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
6.6 Modular Units (defined as factory-produced fixture components and enclosures, site assembled or factory assembled, forming partial or complete bathrooms or private toilet rooms)			X	X	X			
Non-Integrated Enclosures		Space enclosures not integrated with fixture components shall be governed by the Standards for Subsystem: 5.0 Interior Partitions herein with respect to Flame Spread, Smoke Generation, Potential Heat Finish Properties and Acoustics.						
Plastic Units: tests		Modular units composed of gel-coated glass-fiber reinforced polyester resins or thermo-formed acrylics shall meet test requirements in accordance with ANSI Z124.1 and 2-1967 for the following:						

SUBSYSTEM: 6.0 PLUMBING

ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
		Drain Fitting Threshold and Bottom Area Impact Point Impact Water Absorption Water Resistance Color Fastness Stain Resistance Surface Test Cleanability and Wear Standard Dirt Test						
flame spread		Flame spread rating shall not exceed 235 when tested in accordance with ASTM E84-67, or within one inch line-out when tested in accordance with ASTM D635-56T.						
Safety-Acoustics		Modular units shall neither compromise nor prevent attainment of STC, NC or Fire Resistance Classification Standards required for other Subsystems herein.						
6.7 Compatibility		Plumbing Subsystem shall be designed to interface with other subsystems herein.	X	X	X	X	X	X

SUBSYSTEM: 7.0 HVAC

ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
7.1 General	Chapter 8, Articles 8.1 through 8.5, 8.9 and 8.10, provides for determination or eligibility and mechanical criteria for air conditioning, evaporative cooling and dehumidification; and mechanical criteria for heating and mechanical ventilation, including design factors, economic considerations and descriptions and considerations for subsystems and components.	Unless otherwise stated herein, minimum Recommended Standards for this Subsystem shall be governed by DOD, insofar as its requirements are expressed in terms of measurable performance (e.g., Subparagraph 8-1.3.1), but exclusive of such specific design solutions implied therein which may limit the economic utilization of alternate methods of conformance with these Standards (e.g., Subparagraph 8-1.3.2).	X	X	X	X	X	X
7.2 Structural Effect Deflection		This Subsystem shall accommodate deflections permitted in other Subsystems herein.	X	X	X	X	X	X
Load Transmission		Static and dynamic loads arising from this Subsystem shall be transmitted with no adverse effect on Subsystem: 1.0 Structure herein.	X	X	X	X	X	X

SUBSYSTEM: 7.0 HVAC			ADM	BOQ	EMB	STO	CLR	TAM
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS						
7.3 Safety Personnel		This Subsystem shall be designed to afford protection to occupants and operating personnel in accord with applicable requirements of ABA, ANSI, ASME, NFPA and UL.	X	X	X	X	X	X
Fire		This Subsystem shall be designed in accordance with requirements of NFPA Std. 90A.	X	X	X	X	X	X
7.4 Acoustics Sound Isolation		This Subsystem shall neither compromise nor prevent attainment of the NC (Noise Criterion) or STC (Sound Transmission Class) Standards required for other Subsystems herein (20) (17) (23).	X	X	X		X	
Noise Level		Noise level resulting from this Subsystem, when supplying air at 3 CFM/sq.ft. to occupied areas, shall not exceed: dwelling areas: NC 40 offices, classrooms: NC 35 (23).	X	X	X		X	

SUBSYSTEM: 7.0 HVAC			ADM	BOQ	EMB	STO	CLR	TAM
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS						
7.5 Air Pollution	Air pollution from military installations shall be held to a mimimum, and abatement provided in accordance with DOD Instruction No. 4120.9.	Design of this Subsystem shall conform to the applicable requirements of local, state or national authority having jurisdiction at the site of the Facility, whichever is more stringent.	X	X	X	X	X	X
7.6 Durability		Fixed, central subsystems with motors and/or pumps shall have a service life of not less than 15 years; non-accessible elements, e.g. piping shall have a service life equal to the facility in which installed.	X	X	X	X	X	X
7.7 Maintainability		This Subsystem shall be designed and installed to permit repair or replacement readily during its service life, and without removal of other elements or Subsystems for access.	X	X	X	X	X	X
7.8 Compatibility		HVAC Subsystem shall be designed to interface with other Subsystems herein.	X	X	X	X	X	X

SUBSYSTEM: 8.0 ELECTRICAL								
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
8.1 General Codes	Lighting and power systems in accord with NEC as published by NFPA.	Same as DOD, i.e., design of this Subsystem shall be in accordance with the National Electrical Code, NFPA No. 70-1968.	X	X	X	X	X	X
Standards: lighting	Design and intensities in accord with IES Lighting Handbook	Same as DOD, i.e. lighting design and intensities for this Subsystem in accordance with IES (24) for dwelling areas and IES (25) for other locations.	X	X	X	X	X	X
luminaries	Shall conform to UL Publication No. 57, Standard for Electric Lighting Fixtures	Same as DOD	X	X	X	X	X	X
materials and equipment	Conform to Federal Specifications or standards of UL, NEMA, IEEE and ANSI.	Same as DOD	X	X	X	X	X	X
8.2 Structural Effect Deflection		This Subsystem shall accommodate deflections permitted in other Subsystems herein.	X	X	X	X	X	X

SUBSYSTEM: 8.0 ELECTRICAL								
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CLR	TAM
Load Transmission		Static loads arising from this Subsystem shall be transmitted with no adverse effect on other Subsystems herein, including connections capable of transmitting 5 times the dead weight of lighting elements without failure.	X	X	X	X	X	X
8.3 Safety Fire		Elements of this Subsystem penetrating or contained within other Subsystems herein shall not impair the fire resistance Standards of those Subsystems.	X	X	X	X	X	X
Flame Spread		Flame spread rating of non-metallic parts of lighting elements shall not exceed 25 when tested in accord with ASTM E84-67.	X	X	X		X	
Smoke Generation		Maximum specific optical density of smoke generated by non-metallic parts of lighting elements shall not exceed 300 when tested in accord with ASTM STP 422 (14).	X	X	X		X	

SUBSYSTEM: 8.0 ELECTRICAL			ADM	BOQ	EMB	STO	CLR	TAM
ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS						
Emergency Lighting	Required for certain areas where continuance of operation or protection of life or property is essential.	When required by the functional program for the facility, emergency lighting system shall meet the requirements of NFPA No. 101-1966.	X	X	X	X	X	X
Automatic Fire Alarm	Required for combustible Bachelor Officer Quarters	Shall meet requirements of NFPA No. 71-1970 and NFPA No. 72A-1967.		X				
Manual Fire Alarm	Required for Barracks, Bachelor Officer Quarters without automatic alarm, and Administration Buildings and Schools housing 20 or more persons.	Shall meet requirements of NFPA No. 71-1970 and NFPA No. 72A-1967.	X	X	X		X	
Exit Lighting	Shall conform to NFPA Life Safety Code	Same as DOD, i.e. NFPA No. 101-1966.	X	X	X	X	X	X
8.4 System Characteristics	Shall be selected to provide for most efficient and economical distribution of energy.	Same as DOD	X	X	X	X	X	X

SUBSYSTEM: 8.0 ELECTRICAL

ELEMENTS/CHARACTERISTICS	CURRENT DOD CRITERIA	RECOMMENDED STANDARDS	ADM	BOQ	EMB	STO	CL.R	TAM
8.5 Acoustics Sound Isolation		This Subsystem shall neither compromise nor prevent attainment of the STC (Sound Transmission Class) Standards required for other Subsystems herein (12) (20) (17).	X	X	X	X	X	X
8.6 Maintainability	Junction and pull boxes, and similar points shall be readily accessible; when runs above corridors and ceilings, in pipe chases or trenches, install access panels for proper maintenance and operation of electrical distribution system.	This Subsystem shall be designed and installed to permit repair or replacement readily during its service, life, and without removal of other elements or Subsystems for access.	X	X	X	X	X	X
8.7 Compatibility	Lighting equipment and layout shall be coordinated with othér facilities to prevent interferences and to promote good appearance.	Electrical Subsystem shall be designed to interface with other Subsystems herein.	X	X	X	X	X	X

PART III: COMMENTS AND RECOMMENDATIONS

Comments

It is apparent that the present DOD Manual is largely inappropriate for the evaluation, procurement and monitoring of performance-in-use of Industrialized Building Systems.

Notwithstanding the obvious professionalism and expertise underlying the conclusions expressed in several of DOD's Chapters, it is evident that many of these are derived from experience with traditional materials, techniques and procurement methods, local influences and flexible cost/ time/quality criteria.

Literal compliance with the present requirements of the DOD Manual can have the effect of forced solutions, and of denial to the users of the benefits of advanced technology extant in industry and segments of the design professions.

With the dramatic rate of escalation in construction costs and the diminishing availability of craftsmen, it has become obvious to those engaged in long-term building programs that a totally new approach is mandatory. Substantiation of this is evidenced by the number of new "systems-oriented" procurement programs being launched in both private and public sectors of the economy, as well as the investments being made by industry in preparation for participation in industrialized building systems for the market.

Recommendations

It will be apparent to the professionally-trained, perceptive reader of this Report that many of the Recommended Standards are not readily applicable, across-the-board, to certain of the building types considered, nor perhaps to any building type in the absence of finite program requirements or planning criteria.

An aggregation of available subsystems which individually conform to these Standards may very well not result in an integrated solution to the functional requirements of a given facility, nor be more economical in first or service-life cost.

Thus it is recommended that, prior to procurement, a program be developed to include planning guidelines and constraints, plus in-depth requirements for modularity and compatibility, and addressed to a specific building type or family, e.g., ADM-CLR, BOQ-EMB. STO-TAM.

Such a program should also include the development of detailed performance specifications, contract documents prescribing requirements for evaluation submissions, bid submissions, sub-system mock-ups, construction of prototypes for performance testing, and other procedures for the proper implementation of the program.

Similar programs have been conducted successfully for housing and educational facilities; the relatively simple requirements of the military facilities investigated herein, coupled with their potential market volume, should assure optimum utilization of industrialized building systems. It is also probable that initial and owning/operating costs will be more tenable than those produced by adherence to conventional construction methods, materials and solutions.

Admerco, Inc.
Ador/Hilite (Division of Rusco Industries)
Adrian Housing Corporation
Airfloor Company of California
Albers Manufacturing Company, Inc.
Alcan Design Homes Limited
Allied Manufacturing Company
Aluminum Company of America
American Classic Homes
American Eagle (Division of Tamko)
American Home Industries
American Group, Inc.
American Modular Homes Corporation
American Modular Systems
American Systems Building Company, Inc.
Anning Johnson Company
Arbor Modules, Inc.
Armco Steel Corporation
Armstrong Cork Company
Berwick-Lewis, Inc.
Best Homes, Inc.
Bennett Modular Highrise Systems
Bendix Corporation
Behring Corporation
Bartoli and Brady Enterprises, Inc.
Barns Lumber and Manufacturing
Bernard Lumber Company, Inc.
Berns Air King Corporation
Binkley Company
C. W. Blakeslee and Sons, Inc. (Subsidiary of Westinghouse)
Branstrater Engineering Corporation
Briggs Manufacturing Company
Builders Homes, Inc.
Building Components, Inc.
Building Systems, Inc.
Building Systems, Inc. (Subsidiary of Palensky Industries, Inc.)
Building Systems International
Burkhardt Steel Corporation
Burns Brick Company
Butler Manufacturing Company
Capital Industries, Inc.
Cardinal Industries, Inc.
Cary-Way Portable Building Company
Cerus U. S. A., Inc.
Ceco Corporation, Inc. (Mitchell Engineering Division)
Ceiling Dynamics, Inc.
Celandyn Corporation
Chrysler Corporation (Airtemp Division–
Churchs Component Homes
Clary Corporation
Classroom Leasing Company
Commodore Corporation
Component Building Systems, Limited
Component Homes, Inc.
Components, Inc.
Continental Homes, Inc.
Continental Homes of New England, Inc. (Division of Weil-McLain)
Coronis Framing Systems, Inc.
Customhouse Builders, Inc.
Creative Buildings, Inc.

Cust-A-Com Homes (Division of Dumlap and Company, Inc.)
Custom Building Components (Division of Plaza Lumber Company)
Custom Crafted Homes (Division of Springfield Builders Supply Company)
Cyclops Corporation
Davidson Sash and Door Company, Inc.
Daybrite
Delta Modular Division
Delta Steel Buildings Company
Descon/Concordt
Dixie Royal Homes
Dunham-Bush, Inc.
Duval Lumber and Supply Company
Duwe Precast Concrete Products
Dyna-Strux, Inc.

Econostrut Systems
Edwards Engineering Corporation
Electro-Mechanical Corporation, EMC Shelters
Electro/Systems, Inc.
Endure Products, Inc.
Environmental Systems International
Factory Built Homes, Inc.
Featherock, Inc.
Federal Cement Products, Inc.
Federal Pacific Electric Company
Fidelity Homes of America, Inc.
Five Points Housing Consortium
Fleetwood Enterprises, Inc. (Modular Housing Division)
Foamcor, Inc.
Foldcrete International
Fontaine Modular Structures, Inc.
Ivon R. Ford, Inc.
Fruehauf Buildings
General Electric Company
General Environment Corporation
General Matrix Corporation
Genova Products
Geodesic Domes
B. F. Goodrich, Industrial Products Company
Granite City Steel Company
Greg Enterprises, Inc.
Groutlock Corporation of Ohio
Guerdon Industries, Inc. (Mobile and Modular Division)
Hanover Modular Homes, International, Inc.
Harvest Homes (Division of Diamond Point Lumber Company, Inc.)
Harvey Aluminum
Haven-Busch Company
Hexcel Corporation
Hemisphere Development Corporation
Hexagon Homes, Inc.
Hoida Lumber
Holiday Manufacturing Company (Subsidiary of Holiday Inns)
Home Building Corporation
Hough Manufacturing Corporation
Housing 601
Hupp Corporation
Inland Systems
Insta-Building, Inc.
Integral Structures, Inc.
International Shell Structure
Romac Structural Systems, Inc.
James Riber Building Supply Company, (James River Homes)
Henn Air

Jespersen-Kay Systems, Inc.
Kaiser Designed Facilities
Kaiser Gypsum Company, Inc.
Kawnfer Company, Inc.
Keene Corporation
Kemaxco, Inc.
Kingsberry Homes (Division of Boise Cascade)
Kurtz-Gery Corporation
Lancer Modular Homes, Inc.
Morris Lapidus
Leisure Homes, Inc.
Lennox Industries
Levitt Technology Corporation
Liberty Homes (Lewis Manufacturing Company)
Lockheed Aircraft Corporation
Luminous Ceilings, Inc.
Macomber
Macon Prestressed Concrete Company
Magic Homes, Inc.
Mammoth Industries, Inc.
Manufactured Homes, Inc.
Manufactured Homes of California
Marlette Homes, Inc.
Masonite Corporation
Material Systems
Material Systems Corporation
Meridian Modules, Inc.
Mesco Metal Buildings Corporation
Metallic Buildings Systems
Mid America Homes, Inc.
Midwestern Homes
Midwest Prestressed Concrete Company
Miller Homes (Division of Miller Manufacturing Company)
Mitchell Systems (Neil Mitchell Associates, Inc.)
Mobilease
Modufab Corporation
Modular Component Systems, Inc.
Modular Concepts, Inc. (Subsidiary of Franchise Leasing Corporation)
Modular Cores, Inc.
Modular Designed Homes
Modular Housing Systems, Inc.
Modular Management, Inc.
Modular Structures, Inc. (Hercoform Marketing, Inc.)
Modular Services, Inc.
Modular Wall Systems (Godley Const. Co.)
Module Communities, Inc.
Module Construction, Inc.
Myers Brothers Construction Company, Inc.
National Steel Corporation
W. E. Neal Slate Company
New Century Homes, Inc.
Northwest Homes
Omniform, Inc.
Otis International, Inc.
Pacific Modules, Inc.
Panel Fab International
Pantek, Inc.
Pavlex Company
Pemtom, Inc.
Penn Metal Corporation

Portland Cement Association
Precast Systems, Inc.
Precision-Built Corporation
Precision Prestressed Prod.
Prestige Structures, Inc. (Subsidiary of the VTR, Inc.)
Price Brothers
Princess Homes, Inc.
Purex Corporation, Limited (Royal Homes Division)
Reditruss of Florida, Inc.
Reliable Electric Company
Republic Gypsum Company
Republic Modular Homes, Inc.
Republic Steel Corporation
Reynolds Metals Company
Richco Structures (Division of Richardson Lumber Company)
Roanoke Iron and Bridge Works
H. H. Robertson Company
Rockwin Corporation
Rocky Mountain Prestress, Inc.
Rohr Corporation
Romac Steel Co., Inc. (Moduloc)
Rouse-Wates, Inc.
Roycraft Industries, Inc.
Rycenga Homes, Inc.
Joseph Ryerson and Sons, Inc. (Subsidiary of the Inland Steel Company)
Sectional Structures, Inc. (Subsidiary of UGI Group)
Shenango Steel Buildings, Inc.
Shelby Pre Casting Corporation
Shelter Resources Corporation
Soundlock Corporation
Southern Cast Stone Company
Southport Lumber Company (Davidson Industries)
Space Air Products, Inc.
Speedspace Corporation (Division of Potlatch Forests)
Stahl Industries, Inc.
Standard Systems, Inc.
Stanford Builders
Stanley Works
Star Manufacturing Company
Sterling Custom Homes Corporation
Stirling-Homex Corporation
Stran-Steel Corporation
Stresscon Industries, Inc.
Suburban Homes Corporation
Superior Modular Homes
Tappan Company
Techbuilt (Division of Riegel Paper Corporation)
Timber Truss Company, Inc.
Top Roc Corporation
Townland Corporation
TransAmerica Homes Company
Trojan Steel Corporation
Truss and Component Company
Tucker Steel
Tulsa Rig, Reel and Manufacturing Company (Component Division)
U. S. Modules, Inc.
U. S. Plywood
Unibuilt Structures (Division of Reasor Corporation)
Unicon Parking Structures
Union Manufacturing and Supply Company, Inc.

Uniroyal Chemical Company
Unistrut Corporation
Unit Shelter Systems
Universal Papertech Corporation
Universal-Bundle Corporation
Upson Company
Urban Systems Development (Building Systems Division)
United States Steel (Realty Div.)
Vandalia Sales, Inc.
Van-Ler Homes,Inc.
Villaume Industries
USCO, Incorporated
Varco-Bruden
Walker/Palkersburg
Wausau Homes, Inc. and Affiliate
Weston Homes, Inc.
Winston Modular Housing, Inc.
Winnebago Industries, Inc.
Whelans, Inc. (Components Division)
Wickes Corporation
Wilson Concrete Company
Woven Structures, Inc. (Subsidiary of Hitco)
Yetter Homes, Inc.
York Corporation (Division of Borg Warner)
Z Industries, Inc.
H. B. Zachry Company
Maryland Housing Corporation
Celotex Corporation
Westville Homes Corporation
Wonder Steel Buildings
Ryan Homes
Quality Control Builders
Comanco

APPENDIX C

NON-RESPONDANTS TO THE INDUSTRIALIZED BUILDING SURVEY

Abco Fab
Acme Industries, Inc.
Acorn Structures, Inc.
Advanced Products Development Company, Inc.
Alliancewall Corporation
Allied General, Inc.
Allis Chalmers
Alpha Plus Associates
American Air Filter Company
American Cement Company
American Novawood Corporation
American Standard
American Trico Company
American Wood Systems
American Store Corporation
Andro Corporation (Janitrol Division)
Armstrong and Dobbs Building Materials Company
Aurora Building Complexes
Avco Corporation
Axcomatic Homes, Inc. (Division Axinn and Sons Lumber Company, Inc.)
Babak Systems, Inc.
Basic Investment
Bethlehem Steel Corporation
Belin Systems
Bellaire Products, Inc.
Beetem Lumber and Manufacturing Company (Cerliste Homes Division)
Basalt Rock Company, Inc.
Balency-MBM-US Corporation
Balco Building Systems (Division of M. A. Lombard and Son Company)
Ball Brothers Research Corporation
Bagnal Builders Supply Company
Best Panel Homes
H. W. Blackstock Homes
Borg Warner Corporation
Brooks and Perkings, Inc.
Brunswick Corporation (School Equipment Division)
Bryant Air Conditioning Company
Builders Iron Products, Inc. (Subsidiary of Gondas Corporation)
Building Block Investment Corporation
Burkin Homes Corporation
C and M Homes
California Classics
Camcl, Incorporated
Capitol Woodwords
Carrier Air Conditioning Company
Ceco Marketing
Celanese Corporation
Central Kantucky Supply, Inc.
Certain-Teed Development Corporation (Modular Sciences Division)
Chalienge Developments, Inc.
Charter Corporation (Division of Winston Industries)
Cheim Pre-Fab Homes
Christiana Western Structures, Inc.
Comstruct, Inc.
Compatible Design Systems
Compondform, Inc.
Composite Structures, Inc.
Con-Com System, Inc.
Concept Environment
Concrete Building Systems Company

Concrete Plant Company, Inc.
Condor Coach Company (Formerly Kelson Eng. Co.)
Convenient Industries of America, Munday Homes Industries
Conwed Corporation
Copper Development Association, Inc.
Coral Homes, Inc.
Coremod, Inc.
Corl Corporation
Crane Company
Creative Housing, Inc.
Crossland Homes, Inc. (Division of Vindale Corporation)
Cuckler Steel Span Company
C. A. Dawson and Company
Deck House, Inc.
Delco Steel Fabricators, Inc.
Delta Building Corporation
Deluxe Homes, Inc.
Denton Modular Building System, Inc.
Designaire Home Corporation
Dicker Stack Sack, International
Dierks Forest Products, Inc.
Divco-Wayne, Industries
Donn Products, Inc.
Dues Development Company
Duke Millwork, Inc.
Dukor Industries, Inc.
Durastruct
Eastern Schokrete Corporation
Eastern Modular Corporation
Echo Module Systems, Inc.
Economy Forms Corporation
Educational-Industrial Facilities, Inc.
Electro-Link Systems Limited
Emerson Electric Company
Engineered Components, Inc.
Engineered Buildings, Limited
Environmental Systems
Evans Products Company, Prefinishing Group
Evro Modular, Inc.
Fedder Corporation
Feran Construction Company
Fiberboard Corporation
Fleetwood Homes, Inc.
Foam Technology
Forest City Enterprises, Inc.
Formica Corporation
Francon Limitee
Fuqua Homes
Futurama Homes, Inc.
GBH-Way Homes, Inc.
Gaburrt Structurapid System
G. E. M. Homes, Inc.
General Construction Automation
General Dynamics (Electrical Division)
Zoneline (Division of General Electric)
General Homes Corporation
General Housing Industries
General Module Corporation
Gersten Slager Company
Glas-Tec, Inc.

Go-Con Concrete, Limited
W. M. Grace Construction Company
Gray Company
Green Bay Structural Steel
Grumann Aerospace Corporation
Guardsman Homes
Gypsum Panel Systems
Habitat Group
Ha-Fe-Bi-Ri
Hall Homes
Hallet Homes, Inc.
Hallmark Homes, Inc.
Hamill Homes, Inc.
E. F. Hauserman Company
Hercules, Inc.
Heritage Homes
Hide-A-Way Homes,Inc.
Edward Hines Lumber Company (Components Division)
Housing Development
Housing Systems Company
HuriHom, Inc.
Hus-Key Manufacturing Company
ILC Products Company, Inc.
Idaho Forest Industries, Inc.
Imperial Homes, Inc.
Industrialized Building Systems, Inc.
Inland-Ryerson Construction Products Company
Intermountain Precision-Bilt
Internation Modular Structures, Inc.
International Basic Economy Corporation
International Structures Corporation
International Technology, Inc.
ITT-Nesbitt
Jal-Donn Modular Buildings, Inc.
B. K. Johl
Canadian Johns Manville Company, Limited
Jonathan Housing Corporation
Kellner Lumber Company
Kingsley Modular Homes, Inc.
Kit Manufacturing Company
Kohler Company
Leatherman Lumber Company
Lebon Walker
Lindal Cedar Homes, Limited
Locus Homes International
Low Income Section Housing
Luxury Manufacturing and Supply Company
M and S Structures, Inc.
Macco
Magic Homes of Florida, Inc.
Malone Homes
Martin-Marietta Corporation
Maxi-Homes
Melody Homes Manufacturing
Michelmann Steel Construction Company
Midland Company
Mills Corporation
Modcon-Pacific States Conponents
Modern Homes and Equipment Company, Inc.

Modular Building, Inc.
Modular Community Development, Inc.
Modular Construction Systems
Modular Constructors, Inc.
Modular Development Corporation
Modular Development Corporation
Modular Homes Corporation
Modular Housing, Inc.
Modular Industries
Modular Sciences, Inc. (Shelter Industries Division)
Modular Space Corporation
Modular Space Systems, Inc.
Modular Structures, Inc.
Modular Sciences, Inc.
Module Corporation
Modules, Inc.
Modu-Tech Structures
Monarch Industries, Inc.
R. D. Monroe Construction Company, Inc.
Montgomery State Homes
Morazzani Company
Morgan Company
E. J. Nagy and Associates
National Gypsum Company
National Homes Corporation
National Modular Homes
National Modular, Inc.
National Modular Systems
New Castle Products
New England Homes, Inc.
Noonan-Laing, Inc.
North Main Lumber Products Corporation
Northern Components, Inc.
Ohio Valley Homes, Inc.
Oneil Enterprises, Inc.
Owens Corning Fiberglas Corp. (Indus. and Coml. Const. Mat. Division)
PSI Progressive System, Inc.
Page and Hill Homes, Inc.
Palevsky Industries, Inc.
Paragon Industries, Inc.
Paxton Prestige Homes
Pease Company
Plastic Coating Corporation
Phelps Dodge Cooper Products Corporation
Pioneer Homes (Division of Up-Right, Inc.)
Porta-House
Porta-leria Lincoln Manufacturing
Pre/Built Homes, Inc. (Subsidiary of Intercontinental Industries)
Precast Building Sections, Inc.
Precon Corporation
Precon Industries, Inc.
Pressed Concrete, Inc.
Prestressed Concrete of Colorado
Production Engineers and Associates
Raymur Schools Corporation
Redman Industries, Inc.
Regal Industries, Inc.
Relbec Corporation
Reliable Homes, Inc.
Renfro Associates

Rheem Manufacturing Company
Richardson Homes Corporation
Ritz Craft (Manufactured Homes)
Rohr Industries
Rondesics, Inc.
Roof Trusses Corporation
Royalty Homes, Inc.
Sam Industries, Inc.
Sandler-Bilt Homes
Sanford Enterprises, Inc.
San-Vel Concrete Corporation
Schemenauer
Scholz Homes, Inc.
Seaferro, Inc.
Sectional Housing Systems, Inc.
Sectra America
Serendipity Homes
Seth Lumber Company, Inc.
Shelley Systems, Inc.
Sierra Shell Homes, Inc.
Simpson Timber Company
Skyline Homes, Inc.
R and G Sloane Manufacturing (Division Susquehanna Corporation)
A. O. Smith Consumer Products
Soule Steel Company
Southern Prestressed Conc. Corporation
Space-Crete
Spancrete Industries, Inc.
Spanpark
Square D. Company
Stahl Industries
Standard Home and Company (Division of R. Sweet Lumber Company)
Stannar, Inc.
Stiles-Hatton, Inc.
Strescon Industries
Stressed Structures, Inc.
Structural Plastics Corporation
Structural Systems Corporation
Sunbeam Lighting Company
R. L. Sweet Lumber Company
Martin Sweets Company, Inc.
Swift Industries, Inc.
Syncon
TRW Systems Group
Taco, Inc.
Tadjer-Cohen Associates
Tandy Homes, Inc.
Techcrete Consortium
Technology Consortium, Inc.
Eljer Plumbing Ware Division (Subsidiary of Wallace-Murray Corp.)
Terry Supply Company, Inc.
3M Company
Trane Company
Tripac Development Corporation
Trus Manufacturing Company
Truss and Panel, Inc.
Twin State Component Company
U. S. Gypsum Company
U-Form Systems International

United Module, Inc.
Unitized Homes, Inc.
Universal Modular, Inc.
Urban Design Group
United States Steel Corporation
Versadome Corporation
Vin-Lox Corporation
Visual Educom
Larry Vita
Wallace-Murray Corporation (Eljer Plumbingware Division)
Washington Lumber Company
Westland Homes Corporation
Westinghouse Electric Corporation (Urban Systems Developed Corporation)
Worthington Climatrol Industries
XL, Inc.
Richard Allen Rose
Endure-A-Lifetime Products, Inc. (Division of Pre Bilt Structures)
Concrete Products Corporation
Building Units, Inc.
Cambell Modular Building, Inc.
Housing Systems, Inc.
Milligan Industries, Inc.
Torus Corporation
BRS Industries
Forest Products Laboratory
Miter Buildings
Peterson Company
Porta-Kamp Manufacturing Company
Riverside Steel Construction
G. T. Schjeldahl Company
Unibuilt Industries, Inc.
Unicor, Inc.
Unihab, Inc.
Velcro Corporation
Wahod Built Buildings
Weber Showcase and Fixture Company (Division of Walter Kidde)
Zero Manufacturing Company
John Brennemann
Champion Home Bldg., Co.
Alco Universal, Inc.

APPENDIX D

NON-APPLICABLE RESPONDANTS TO INDUSTRIALIZED BUILDING SURVEY

3-80A

Advanced Equipment Corporation
Air Logistics Corporation
Alumber Company of America
American Plywood Association
Arkla Air Conditioning Company (Division of Arkla Industries, Inc.)
Automated Construction Equipment Company
Binghamton Steel and Fabricators Company
Burton Woodwork (Division of Klein Industries, Inc.)
Cebeton Building Systems Division
City Lumber and Supply Company
Climatrol Industries, Inc.
Coleman Company, Inc.
Day and Night Manufacturing Company
John David Management Company
Dow Chemical Company
Emerson and Company, Emco Devprs., Inc.
Four Seasons Structures, Inc.
Georgia-Pacific
Golden State Consortium
Heritage Homes, Inc.
International Steel Company
Interpace
I. T. E. Imperial
Kaykor Porducts Corporation
Levitt Mobile Systems
Met-Pro Water Treatment Company, Inc.
Mills Modular Homes, Inc.
Modular Manufacturing Company
Module Industries, Inc. (Subsidiary of Shopco, Inc.
Modumatic Building Units
Mod-UI-Fab Homes
National Forest Products Associates
Nickerson Homes, Inc.
Perl-Mack Companies
Ring Brothers Consortium
Singer Company
Skycell Modular Ceil Systems
Spuntech Housing Corporation
Steele and Haurberg Building Supplies, Inc.
Tilton Homes Corporation
Wheeling Corrugating Company (Division of Whelling-Pittsburgh Steel)
Partition Specialties, Inc.
Monsanto Company

APPENDIX E

INTERVIEWS WITH CIVILIAN AGENCIES TO ASCERTAIN PROGRAMMED CONSTRUCTION NEAR U. S. MILITARY INSTALLATIONS

3-81A

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APPENDIX E

INTERVIEWS WITH 30 NON-MILITARY GOVERNMENTAL AGENCIES

SAMPLE INTERVIEW

1. What would you estimate as the total dollar value for all programmed construction (for your agency) over the next 5 years.
2. What types of buildings are planned? (i.e., administrative facilities etc. by number of buildings for each type).
3. Do you have a breakdown of the total dollar value by building type? (If no), can you approximate the dollar allocation by building type?
4. Where, generally, will these buildings be constructed? (list cities, counties, etc.).
5. What are the tentative construction dates for each type and/or location? (By quarter of year, i.e., 4th quarter, 1974.)
6. Have any of the proposed buildings already been designed?
7. What is your agency's opinion, if any, of industrialized buildings for use in your building program? (refrain from using the term "pre-fabricated").
8. What building type(s) in your program would you consider most suitable for systems adaptation? (Industrialized building components, such as pre-cast concrete floors.)
9. Would your agency be favorable to the idea of forming a consortium with the Corps of Engineers for the purpose of buying industrialized building components—with the objective of overall cost reduction?
10. What constraints would you envision coming into play in such a relationship with the U. S. Army?
11. Basically, would you consider the idea worthy of further study?

CITY OF ALEXANDRIA, VIRGINIA
DEPARTMENT OF PLANNING
ALEXANDRIA, VIRGINIA

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
Classroom - Training		1971-1974	$3.9
Vehicle Maintenance			
Fire Stations		1972-1976	0.6

Inasmuch as the latest budgetary allocations will not be available before May 1, 1971, the Department of Planning for the City of Alexandria presented the above data with warning that there may be significant changes. The total value of programmed construction over the next 5 years, under the current budget, is approximately $12 million. The $4.5 million reflected above represents that portion which is pertinent to this study.

While generally favorable to the idea of forming a consortium with the Corps of Engineers,the city planners were not in favor of using materials of an industrialized nature for the city's purposes.

CITY OF ALEXANDRIA, VIRGINIA
PUBLIC SCHOOLS–GENERAL SERVICES
ALEXANDRIA, VIRGINIA

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value
Classroom - Training		1971-1975	$724,300

The programmed construction activity of this public school system for the next five years, is, at present, limited to remodeling ($324,300) and one multi-room addition to an existing facility ($200,000). A new elementary school valued at $2,200,000 was recentl y constructed and will be ready for occupancy in the Fall of 1971.

The Director of General Services for the school system was of the opinion that a new senior or middle school would be erected only if a current bid to annex part of Fairfax County passes, or if there is an unexpected surge in the population within the next five years. For these reasons, he did not believe that the building program size merited consideration of a mass purchasing consortium with the Corps of Army Engineers.

COUNTY OF FAIRFAX
FAIRFAX, VIRGINIA

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
Classroom - Training		1971-1976	$120.0
Repository Facilities			5.5
Libraries		1971-1976	4.5
Storage			1.0
Vehicle Maintenance			
Fire Stations	4		2.0
Administrative	2	1972-1975	10.0

The count

The County of Fairfax, Virginia represents one of the best possibilities for mass purchasing of industrialized buildings, assuming that traditional inter-governmental proglems can be resolved and kept to a minimum. Fairfax, Virginia is the largest and fastest expanding section of the metropolitan Washington, D. C. There is still room for tremendous expansion, growth and development in Fairfax.

FORT BELVOIR, VIRGINIA

Arlington County, Va.
City of Alexandria, Va.
  Department of Housing & Community Development
  Department of Planning
  Public Schools—General Services
County of Fairfax, Va.
District of Columbia
Fairfax County, Va.—Public Schools
George Mason College
Maryland Council for Higher Education
Montgomery County, Md.—Public Schools
Northern Virginia Community College
Prince William County, Va.
State of Maryland
  Board of Community Colleges
  Department of General Services
University of Maryland
U. S. General Services Administration

ARLINGTON COUNTY VIRGINIA
ARLINGTON, VIRGINIA

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
CLASSROOM-TRAINING		1972-1976	$12.0
ADMINISTRATIVE:			
Courthouse		1972	2.5
Ofc. of Human Resources		1972	2.4
VEHICLE MAINTENANCE:			
Fire Station		1972	0.4

Arlington County Virginia has a total of $86 million in programmed construction planned for the next five years. $20 million of this total has already been funded of which $17.3 million is shown above.

The county representative's opinion of industrialized buildings was basically favorable. He pointed out the preference of temporary buildings and classroom facilities over other adaptations. However, he was not receptive to the idea of Arlington County's participation in a mass purchasing consortium with the Corps of Engineers.

CITY OF ALEXANDRIA
DEPARTMENT OF HOUSING & COMMUNITY DEVELOPMENT
ALEXANDRIA, VIRGINIA

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
Not Applicable	0	1971-1975	0

Inasmuch as this agency is concerned only with the economic development of Alexandria, Virginia, they were unable to contribute to the overall objectives of this study.

While the officer of planning and financial management was quite receptive to the idea of industrialized buildings, they qualified their endorsement of a consortium with the Corps of Engineers as follows:

a) approval by county executives
b) possible need to stockpile materials withe Corp and require that project Contractor purchase materials from that stockpile.

DISTRICT OF COLUMBIA
OFFICE OF GENERAL SERVICES
WASHINGTON, D. C.

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
Classroom - Training		1971-1975	$250.0
Vehicle Maintenance Fire Department		1971-1975	30.0
Administrative Welfare Facility		1971-1975	40.0

The District of Columbia is quite receptive to the ideas of: (A) using industrialized building components and (b) forming a consortium with the U. S. Army Corp of Engineers for mass purchasing of materials. The Assistant Director in the Office of General Services questionned the legality of such a relationship between the District and the Corp of Engineers. Currently, there is a bill before Congress which would permit Washington, D.C. to jointly purchase materials with the State of Maryland, where industrialized components are being produced in factories.

FAIRFAX COUNTY, VIRGINIA PUBLIC SCHOOLS
DESIGN, CONSTRUCTION & SITE ACQUISITION DIVISION
FAIRFAX, VIRGINIA

BUILDING TYPE	No. of Gldgs.	Time Frame	Dollar Value (Millions)
Classroom - Training		1971-1975	$125

The $125 million programmed construction for the Fairfax County, Virginia Public School System includes new elementary, intermediate and high schools as well as modernization and additions to existing schools. The bulk of the new construction will be in the western half of the county, with some already designed.

The design and construction division considered the use of industrialized buildings for public schools as programmatically unacceptable in light of their overall requirements. Although extremely interested in cost reduction methods, mass purchasing of industrialized building systems was regarded as uneconomical.

GEORGE MASON COLLEGE
FAIRFAX, VIRGINIA

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
Classroom - Training		1975-1976	$9.0
Administrative		1976	1.0
Dormitory		1974-1976	6.0
Repository Facilities			
Library		1974	3.0
Other		1974	0.5

George Mason College anticipates approximately $30 million in new buildings over the next 5 years. The $19.5 million reflected above constitutes that portion which is compatible with the building types considered in this study.

Although the college is state-owned and operated, it is not singularly interested in being a part of a mass purchasing consortium. The primary reason given for this negative reaction was the necessity for reassignment of the college's long-range plans in view of the overall purchasing requirements of the consortium. This requirement would be very difficult for an institution with a 25 year construction program.

An unfavorable attitude toward industrialized buildings was also assessed. The college representative felt that this construction technique would be suitable for certain maintenance and service facilities and that precast concrete was most formidable. However, the architect makes decisions on his own with regard to materials and the college would have little influence in that area of endeavor.

MARYLAND COUNCIL FOR HIGHER EDUCATION
ANNAPOLIS, MARYLAND

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
Classroom - Training	6	1972-1976	$17.7
Administrative	1	1972-1974	1.2
Repository			
New Library	1	1972-1973	1.2
Addition to Library	1	1972-1973	1.1

The Maryland Council for Higher Education provided the above information on the programmed construction plans for three state colleges within 50 miles of Fort Belvoir, Va. The institutions of higher education and their respective total dollar values of capital outlay over the next five years are:

Bowie State College, Prince George County	$14.3 million
Coppin State College, Baltimore City	9.4 million
Morgan State College, Baltimore City	26.9 million

The total dollar values include renovations, site acquisitions, planning costs and building equipment, as well as actual construction costs. The dollar values presented by building type are abstracts for three specific building types—Construction Costs Only.

Mr. K. L. Robinson, Specialist for Facilities, reacted favorably to the idea of the state colleges forming a consortium with the Corps of Engineers for the purpose of mass purchasing of industrialized building components. He cautioned, however, that it might not be economically feasible unless it was set-up properly and operated efficiently.

MONTGOMERY COUNTY SCHOOLS
ROCKVILLE, MARYLAND

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
Classroom - Training			
Elementary Schools	2	1971-1972	$45.6
	4	1972-1973	1.1
	3	1973-1974	4.0
	3	1974-1975	4.3
	3	1975-1976	4.3
Secondary Schools	1	1971-1972	1.9
	5	1972-1973	10.9
	2	1973-1974	4.8
	3	1974-1975	6.8
	1	1975-1976	2.7

The Montgomery County, Maryland School District has an extremely active building program as evidenced by the above allocation of construction expenditures. Furthermore, as of the survey, only two elementary schools and two high schools had been designed, making the potential very high for utilization of industrialized building components in this county.

Dr. G. Kent Stewart, Director of School Facilities, was not opposed to forming a consortium with the Corps of Engineers, providing adequate planning time preceeded acquisition of materials. Although potential conflicts between Federal, State and Local Officials was envisionable, Dr. Stewart felt that the idea merited further study.

NORTHERN VIRGINIA COMMUNITY COLLEGE
ANNANDALE, VIRGINIA

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
Classroom - Training		1971-1975	$25.0
Administrative		1971-1975	5.0

(Note: Allocation Estimated)

Northern Virginia Community College has programmed construction of classrooms, administrative offices, laboratories and learning resource centers scheduled for the following campuses in Northern Virginia over the next five years:

Central Campus - Annandale	$2.5
Eastern Campus - Alexandria	9.0 (designed)
Southern Campus - Dale City	6.0
Western Campus - Manassas	6.5
Northern Campus - Loundoun County	6.0

Construction will be completed in two stages: September, 1974 and September, 1976.

The community college has an outstanding building program with some industrialized components in current usage—beams and walls. It has also participated in the purchase of materials from the State of Virginia at reduced costs, and is thoroughly familiar with mass purchasing techniques.

Mr. Robert C. Daly—Coordinator of Planning and Development—is of the opinion that there would have to be a provision instructing contractors to purchase materials from the Corps of Engineers if a consortium of the type in mind were implemented. The question of the quality of materials and their application to different designs of the various consortium members was raised. He is extremely interested in the idea and suggests that further study definitely be made.

PRINCE WILLIAM COUNTY, VIRGINIA
WOODBRIDGE, VIRGINIA

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
Administrative	1	1972-1974	$6.0
Vehicle Maintenance			
Fire Stations	4	1971-1974	0.5
Dormitory			
Juvenile Detention Home	1	1971-1972	0.3
Classroom - Training			
Mental Retardation	1	1971-1972	0.5
Public Schools	30	1971-1975	62.0
Repository Facilities			
Libraries	5	1971-1975	2.5

The $72 million in programmed construction outlined above represents ½ of the total capital improvement plan for Prince William County, Virginia. The balance is allocated to hospitals, human resources facilities and others outside the 6 building types considered in this study.

Mr. Henry G. Bibber, Assistant County Planner, was most receptive to the programmed purchasing of industrialized building components. However, any implementation would be subject to the endorsement and approval of the Board of Supervisors. The monumental financial problems associated with bond referendums would also have to be resolved.

STATE OF MARYLAND
BOARD OF COMMUNITY COLLEGES
ANNAPOLIS, MARYLAND

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
Classroom - Training		1971-1975	$30.0
Administrative		1971-1975	17.5

(Note: Allocation Estimated)

The Maryland Board of Community Colleges is the state agency for 16 autonomous colleges in the State of Maryland. The state-wide construction program for all building types, 1971-1977 is valued at $200 million. Approximately $135 million will be realized within the 5 year period 1971-1976 under investigation. Although only 9 of the 16 colleges are within 50 miles of Fort Belvoir, Va., 80 to 90 percent of the programmed construction was estimated to be within the prescribed radius. A total of $47.5 million for classroom-training facilities and administration buildings is projected as that portion of the $135 million which would accrue to these two building types.

Dr. Lewis Fibel, Executive Director for the Board, considers the utilization of industrialized buildings for classroom and office facilities economically desirable. However, he hastened to state that there might be opposition in view of the fact that the individual colleges do their own building design and construction.

STATE OF MARYLAND
DEPT. OF GENERAL SERVICES
BALTIMORE, MARYLAND

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
Administrative	1	1972	$6.6
Repository			
Storage Warehouse	1	1972	0.2
Dormitory			
Juvenile Detention Homes	2	1972-1973	1.1

The Department of General Services for the State of Maryland handles all stages of a construction project for all state buildings and non-building projects. The total capital outlay (of which new buildings is a fraction) for the State of Maryland over the next 5 years approximates $5 billion. Those building types of interest to this study and within 50 miles of Fort Belvoir, Va. are reflected above. 75 percent of all proposed building projects are in some stage of the overall design process.

While the Department of General Services is not diametrically opposed to the concept of industrialized buildings, it envisions any employment thereof as a function of the relationship which it would have with the Corps of Engineers and the degree to which it would or would not conflict with dominate styles of architecture.

UNIVERSITY OF MARYLAND
COLLEGE PARK, MARYLAND

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
Apartments	100	1971-1974	$ 7.5
Administrative	5	1971-1974	25.0
Classroom-Training	22	1971-1974	65.0

The University of Maryland has $105 million in programmed construction over the next 5 years, of which $97.5 million is reflected above in 3 building types. It's $7.5 million in apartment type residence halls is the only contribution to that building type emanating from the survey in the Fort Belvoir, Va. area.

Interestingly, the University plans to build the 100 apartments using all pre-fabricated modular units. The Director of University Planning, Col. Robert Kendig, very much favors the end of "everyone re-inventing the wheel" practice in building design and construction and thinks that the University should be able to use designs already existing. He says that the University will add considerably to its facilities in the next ten years, and with the ever-increasing costs of construction, he sees a definite need for industrialized buildings. However, he emphasized that state agencies generally tend to oppose change, especially change as revolutionary as this.

U. S. GENERAL SERVICES ADMINISTRATION
REGIONAL OFFICE
WASHINGTON, D.C.

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
Classroom - Training	2	1971-1975	$ 41.5
Administrative			323.5
Repository Facilities:			
Post Office	1	1971-1975	41.2

The U. S. General Services Administration was most cooperative in releasing the above figures for programmed construction within a 50 mile radius of Fort Belvoir, Virginia. While 80 percent of the buildings have already been designed, GSA was most anxious to explore further the feasibility of forming a mass purchasing consortium with the U. S. Army Corps of Engineers. They are, similarly, favorable to the idea of industrialized buildings for those facilities constructed, owned and operated by GSA.

Several constraints were envisioned with respect to GSA and DA relationships, Firstly, the problems of operating within the existing statutes controlling both the Army and GSA would have to be analyzed and resolved. Secondly, the necessity for getting "recess" funding tied up so that both GSA and Army would be in proper relationship with each other. Finally, the various problems associated with inter-agency agreements would have to be tackled.

FORT BENNING, GEORGIA

Columbus College, Columbus Ga.
Housing Authority of Columbus, Ga.
Muscogee County, Ga.—School District
Phenix City, Ala.—School District
State of Georgia Highway Department

COLUMBUS COLLEGE
COLUMBUS, GEORGIA

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
Repository Facility:			
Library	1	1972	$2.3
Dormitory			2.7

Columbus College is one of the 27 colleges in the Georgia Board of Regents System. If the utilization of industrialized buildings could be sold here, it would possibly be applicable on a state-wide basis.

Mr. Dunham, the college representative who was interviewed, was definitely not in favor of industrialized buildings as he felt no real economies of scale could be effected. 40 percent of the buildings in the college's $5 million construction program for 1971-1975 have already been designed.

Mr. Dunham stated further that as far as he knew, the bonding regulations for the State of Georgia would not permit joining a consortium.

HOUSING AUTHORITY OF COLUMBUS, GEORGIA
COLUMBUS, GEORGIA

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
Apartment:			$20
Housing—Elderly		1971-1975	6
Housing—Regular			14

The Housing Authority of Columbus, Georgia has considerable housing needs for elderly, military families and dislocated persons due to planned urban redevelopment. Although the number of apartment buildings is undetermined, the dollar allocation was assured, pending adequate funding. None of the proposed buildings have been designed.

This agency has a favorable opinion of industrialized buildings, qualified by the extent to which HUD regulations will allow their use. They would also be willing to explore the advantages and constraints realized by forming a consortium with the Corps of Army Engineers.

MUSCOGEE COUNTY SCHOOL DISTRICT
COLUMBUS, GEORGIA

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
Classroom-Training	10-12	1971-1975	$10

The programmed construction for the Muscogee County School District over the next 5 years includes extensive alterations, additions and new structures. Although none of the planned buildings have as yet been designed, the basic design for future schools will be similar to that of those already built.

The superintendent of this school district was very vehement in his opinion that only conventional construction will fulfill his needs. He has listened to several vendors of industrialized buildings and does not like any of the concepts employed in their presentations.

An unfavorable reaction to forming a consortium with the Corps of Engineers was expressed. The primary reason given was the constraint which would be effected by local building codes for public buildings. Further study of the idea was also discouraged largely for the same reasons.

PHENIX CITY SCHOOL DISTRICT
PHENIX CITY, ALABAMA

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
Classroom - Training	2-3	1971-1975	$5.0

The Phenix City School District serves the Alabama portion of the Greater Columbus, Georgia–Fort Benning Metropolitan Area. Similar reactions to the concept of industrialized buildings and mass purchasing techniques expressed by the Muscogee County, Georgia School District were received from the Phenix City School District: (1) the desire to retain conventional public buildings; (2) the overt undesirability of forming a consortium with the Corps of Engineers.

Two additional comments were made by the Phenix City School District. Firstly, it was felt that no real savings would accrue through the use of industrialized buildings. Secondly, funding regulations as set up at the present time would constrain any mass purchasing efforts.

STATE OF GEORGIA HIGHWAY DEPARTMENT
THIRD DIVISION
COLUMBUS, GEORGIA

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value
Vehicle Maintenance	2-3	1971-1975	$25,000

The limited building needs for a state highway department would not justify consideration of a purchasing consortium. While this fact was initially recognized, the third division field office for the State of Georgia Highway Department was contacted to ascertain their opinion of industrialized buildings and building systems.

The overall savings realized through the use of State Highway Department road workers in constructing buildings when time permits, and as needed was the underlying reason for a negative reaction to industrialized buildings. The agency also felt that state funding regulations would inhibit any mass purchasing plans.

FORT KNOX, KENTUCKY

City of Louisville, Ky.
- Board of Education
- Department of Public Works

Jefferson County, Ky.
- Board of Education
- Department of Public Works

University of Louisville
U. S. Dept. of Housing & Urban Development

LOUISVILLE BOARD OF EDUCATION
LOUISVILLE, KENTUCKY

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
Classroom - Training		1971-1975	$0.5

The Louisville Board of Education has experienced in the past and is projecting a non-growth situation over the next 5 years. The enrollment figures have not appreciably changed in at least 5 years. They indicated that there is no new construction planned and that their money will be spent in maintenance and renovation.

This agency does not feel that they can participate in a consortium with the Corps of Army Engineers since they are not planning any new construction. They feel that industrialized buildings are too expensive. Further study was discouraged for these reasons.

CITY OF LOUISVILLE–DEPARTMENT OF PUBLIC WORKS
LOUISVILLE, KENTUCKY

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
Not Applicable	0	1971-1975	0

The programmed construction for the City of Louisville–Department of Public Works–was not applicable to this study because it was all non-building construction.

JEFFERSON COUNTY BOARD OF EDUCATION
LOUISVILLE, KENTUCKY

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
Classroom - Training	3	1971	$8.0
	3	1972	8.0
	3	1973	8.0
	3	1974	8.0
	3	1975	8.0

The Jefferson County Board of Education has planned a $40 million program over the next 5 years. Their emphasis is in new school construction with some new additions to existing schools.

The reaction to industrialized buildings by this agency was positive if the cost factors were favorable. They would consider a consortium with the Corps of Engineers after additional studies and more information was available.

JEFFERSON COUNTY–DEPARTMENT OF PUBLIC WORKS
LOUISVILLE, KENTUCKY

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
Not Applicable	0	1971-1975	0

The programmed construction for Jefferson county–Department of Public Works–was not applicable to this study as it consisted entirely of road and bridge work.

UNIVERSITY OF LOUISVILLE
LOUISVILLE, KENTUCKY

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
Classroom - Training	1	1971	$5.0
Apartment	1	1973	4.5

The University of Louisville has planned their construction to accommodate their projected expansion. Their funding was pending, but assured.

This university, being state supported, depends upon the decisions of the state concerning funding and design guidelines. The university was opposed to industrialized buildings or further study unless the state took a different position.

U. S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
STATE OF KENTUCKY
LOUISVILLE, KENTUCKY

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
Dormitory	8	1971-1975	$14.0
Administrative	3	1971-1975	5.0
Repository Facilities	7	1971-1975	11.0

The anticipated construction over the next 5 years for this agency is approximately $30 million. These projects are based on the projected needs of applicants seeking federal assistance.

The agency is receptive to industrialized buildings if they meet their applicants need. They were not as receptive to continuing the study, but did not see any problems with a consortium with the Corps of Army Engineers.

FORT ORD, CALIFORNIA

County of Santa Clara, California
- Department of Public Works
- Office of Education

San Jose State College

COUNTY OF SANTA CLARA, CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
SAN JOSE, CALIFORNIA

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value (Millions)
Dormitory:			
Elmwood Barracks		1971-1972	$ 0.3
Children's Shelter	1	1971-1972	0.2
Administrative:			
Civic Center Offices	1	1973-1975	11.9
Court Annexes	2	1975-1976	4.5

The County of Santa Clara, California has $43.7 million in programmed construction scheduled for 1971-1975. The $16.9 million indicated above represents the dollar allocation by building type pertinent to this study.

While the Assistant Director for the Department of Public Works indicated that he had little knowledge of industrialized buildings, he felt that the idea of a consortium with the Corps of Engineers was feasible, but merited further study.

COUNTY OF SANTA CLARA, CALIFORNIA
OFFICE OF EDUCATION
SAN JOSE, CALIFORNIA

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value
Not Applicable	0	1971-1975	0

The 38 school districts of Santa Clara County have independent control over their programmed construction capital expenditures.

The Associate County Superintendent, Mr. O. D. Russell, conveyed his opinion of the mass purchasing of industrialized building components by saying that: "without equivocation—the school districts of Santa Clara County—are interested in procedures whereby they may improve management techniques with regard to building acquisition and management."

SAN JOSE STATE COLLEGE
SAN JOSE, CALIFORNIA

BUILDING TYPE	No. of Bldgs.	Time Frame	Dollar Value
Not Applicable	0	1971-1974	0

The Construction and Planning Division of the California State College System stated that an absence of funds had prevented any form of programmed construction scheduling. A library for the San Jose campus has been held in abeyance for over two years.

The state agency, however, has a favorable opinion of industrialized buildings and would be initially agreeable to forming a consortium for mass purchasing of industrialized building components.

ALPHABETICAL LISTING OF AGENCIES INTERVIEWED

Alexandria Public Schools General Services 418 South Washington Street Alexandria, Virginia	Rep: Joseph McGowan Director (703) 750-6365
City of Alexandria, Virginia Department of Housing and Community Development 110 North Royal Street Room 501 Alexandria, Virginia	Rep: Martin Smith (703) 750-6311
City of Alexandria, Virginia Department of Planning and Regional Affairs 125 North Royal Street Alexandria, Virginia	Rep: John Minton (704) 750-6291
City of Louisville, Kentucky Department of Public Works City Hall Louisville, Kentucky	Rep: Warren Webster
City of Phenix City, Alabama Phenix City School District 1212 Ninth Avenue Phenix City, Alabama	Rep: James E. Owen Superintendent (205) 298-0534
Columbus College Algonquin Drive Columbus, Georgia	Rep: Frank Dunham (404) 561-5134
County of Arlington, Virginia Office of the County Manager Arlington County Courthouse Arlington, Virginia	Rep: Vernon Ford Manager's Assistant (703) 558-2401
County of Fairfax, Virginia Department of Planning and Financial Management 4100 Chair Bridge Road Fairfax, Virginia	Rep: Robert Jentsch Director of Planning (703) 691-2646
County of Jefferson, Kentucky Baord of Education 3332 Newburg Road Louisville, Kentucky	Rep: Mr. Gambill
County of Jefferson, Kentucky Department of Public Works County Building Louisville, Kentucky	Rep: Fran Lodge Director
County of Montgomery, Maryland Office of School Facilities 850 North Washington Street Rockville, Maryland	Rep: Dr. G. Kent Stewart Director (301) 279-3425
County of Prince William, Virginia Office of Assistant County Planner 15920 Jefferson Davis Highway Woodbridge, Virginia	Rep: Henry G. Bibber Assistant County Planner (703) 221-1101

County of Santa Clara, California
Department of Public Works
County Administration Building
70 West Hedding Street
San Jose, California 95110

Rep: Robert Perrich
Assistant Director
(408) 299-2424

County of Santa Clara, California
Office of Education
45 Santa Teresa Street
San Jose, California 95110

Rep: O. D. Russell
Assistant Superintendent
(408) 299-2441

District of Columbia
Office of General Services
613 G Street N. W. Room 1114
Washington, D. C.

Rep: Malcolm E. Clark, Jr.
Assistant Director
(202) 629-4574

Fairfax County Public Schools
Design, Construction and Site Acquisition Division
10700 Page Avenue
Fairfax, Virginia

Rep: John Krytusa
Acting Assistant Superintendent
(703) 691-3131

Housing Authority of Columbus, Georgia
100 Wynnton Road
P. O. Box 630
Columbus, Georgia

Rep: Brown Nicholson, Jr.
Executive Director
(404) 324-3411

Louisville Board of Education
506 West Hill Street
Louisville, Kentucky

Rep: Mr. Hassenpflug
(502) 634-3611

George Mason College
4400 University Drive
Fairfax, Virginia

Rep: James Clark
Director of Planning
(703) 591-4600

Muscogee County, Georgia
School District
1200 Bradley Drive
Columbus, Georgia

Rep: Ron Shaw
Superintendent
(404) 323-4351

Northern Virginia Community College
8333 Little River Turnpike
Annandale, Virginia

Rep: Robert C. Daly
Coordinator of Planning & Development
(703) 280-4000

San Jose State College
California State College System
Construction & Planning Division
5670 Wilshire Boulevard
Los Angeles, California 90036

Rep: Raymond Yusi

State of Georgia Highway Department
Field Office - Third Division
River Road
Columbus, Georgia

Rep: John W. Wade
(404) 647-7111

State of Maryland
Board of Community Colleges
Parole Office Center
Annapolis, Maryland

Rep: Dr. Lewis Fibel
Executive Director
(301) 267-5597

State of Maryland
Council for Higher Education
93 Main Street
Annapolis, Maryland

Rep: K. G. Robinson
Specialist for Facilities
(301) 267-5961

State of Maryland Department of General Services 301 West Preston Street Baltimore, Maryland	Rep: Lawrence Sargston Principal Architect (301) 383-3967
State of Maryland Office of State Planning 301 West Preston Street Baltimore, Maryland	Rep: Norman Hebder Deputy Sec. of State Planning Marvin Jensen Acting Director of Capital Improvements (301) 383-3967
University of Louisville Louisville, Kentucky	Rep: Wade Woods
University of Maryland Administration Building College Park, Maryland	Rep: Robert Kendig Director of Planning (301) 454-2713
U. S. Department of Housing & Urban Development State of Kentucky 600 Federal Place Louisville, Kentucky	Rep: William P. Dillon (502) 582-5269
U. S. General Services Administration 18th & F Streets, N. W. Washington, D. C.	Rep: Tom Payton Office of Construction Management (202) 343-4731

APPENDIX F

AN EXAMPLE OF A FEEDBACK SYSTEM FOR INDUSTRIALIZED BUILDING

This section will demonstrate the application of procedures outlined above to industrialized enlisted men's barracks at a Class I U. S. Military Installation.

IDENTIFICATION OF KEY INDICATORS

The key indicators of performance will differ according to the type of industrialized building used. For the purposes of this example the barracks is considered to be constructed of pre-engineered modules, i.e., completely equipped volumes of space as large as transportation restrictions allow.* The modular units are assembled at the site.

Key indicators are derived from those aspects of the performance of industrialized buildings which are expected to differ from the performance of conventional buildings. In this case the key indicators (summarized in Table 3) are:

1. Durability, or the maintenance of acceptable performance over time. It will be measured by cost per year to maintain. Durability of industrialized buildings is affected by:

   a. The quality of materials.

   b. The performance characteristics of joints. (This is especially cirtical, as mechanical joints are used more extensively than in conventional construction.)

   c. The effect upon maintenance and repair costs of interface articulation. (See Notes to Table 1, No. 15.) The accessibility of various subsystems (electrical for example) differs widely between different systems of construction.

2. Acoustic isolation. The lightweight construction technologies employed in industrialized building do not have the inherent acoustic properties of many types of conventional construction. It will be measured by physical testing and surveys of direct users.

3. Flexibility (adaption to a new use). Flexibility may be restricted in buildings composed of a number of transportable modules. Even if the dimensional discipline chosen is successful in resolving the demands of transportation and original function, it may restrict future adaptations. It will be measured by surveys of the indirect users of the buildings.

4. Flexibility (expansion). Flexibility may also be restricted in these buildings by such constraints as:

   a. factors of design which limit the direction, geometry or extent of expansion (horizontally or vertically).

   b. Difficulty (or impossibility) of matching a given closed system module to obtain uniformity in expansion. This aspect of flexibility will also be measured by surveys of the indirect users of the building.

5. Appearance. Differences between conventional buildings and industrialized buildings in materials, detailing, repetitiveness and possible overall configurations will all affect the user's subjective appraisal. Appearance will be measured by surveys of the direct users of the building. The relative priority of this evaluation may be expected to increase in the future.

SELECTION OF SAMPLE

Given these key indicators, it is possible to select a sample of conventional buildings now, which will serve as the basis of comparison to any industrialized buildings constructed in the future. This sample should exhibit a variety of construction technologies. It should be composed of relatively new buildings, to avoid granting an unfair advantage to the industrialized buildings. It should be large enough to generate data which is statistically significant.** The sample should include buildings in a variety of climatic zones, and of course should be restricted to buildings performing the same function: barracks.

*It is certainly possible to use some other type of industrialized building for barracks, for example, open systems of components for selected subsystems, as in the California School Construction Systems Development (SCSD) project. A different type of industrialized building requires different indicators, but the process of choosing and applying key indicators remains the same.

**Choosing a number is difficult, but it appears that a sample of five is too little, a sample of 100 is excessive. 20 would probably be useful.

Table 3

KEY INDICATORS OF PERFORMANCE FOR INDUSTRIALIZED BARRACKS BUILDINGS

		SENSITIVE SUBSYSTEM							
		structure	exterior wall	roof/ceiling	floor/ceiling	interior partitions	plumbing	HVAC	electrical
ASPECT OF PERFORMANCE	durability	X	X	X	X	X	X	X	X
	acoustic isolation (airborne & impact)		X	X	X	X	X (*)	X (**)	
	flexibility (change of use)			X	X	X	X	X	X
	flexibility (expansion)	X	X						
	appearance	X	X	X	X	X	X (*)		

* if plumbing consists of modules, i.e., integrated room-size enclosures
**if unconventional HVAC system is used

TESTING INDUSTRIALIZED BUILDINGS

As soon as some barracks classified as industrialized are constructed, they will be surveyed by the same techniques applied to the selected sample of conventional buildings.

For the remainder of this section, it is assumed that the survey of a sample of existing buildings has already been carried out, and that the same survey techniques are being applied to a new barracks building constructed of factory-made modules.

SURVEY TECHNIQUES

All three survey techniques identified in this report should be used: the keeping and collection of records, physical measurement and the administration of questionnaires. Examples of each data gathering technique are provided.*

At the time the industrialized building is completed, a representative of the OCE will visit the Facilities Director to acquaint him with data collection formats and procedures.

The Maintenance and Repair Report form (Exhibit 2), prepared in advance by the OCE, is to be filled in by the Facilities Director every time a maintenance or repair operation is performed on the building. (The form in Exhibit 2 shows the pre-prepared portions typed and the sample Facilities Director's notations hand written.) The report form is divided into the following sections:

1. Building Description. (Information is drawn largely from the Building Information Schedule by (OCE.)
2. Sub-system Affected. (During initial visit, OCE representative will explain each team to the Facilities Director, and leave a list of definitions with him.)
3. Deficient Component. (A brief verbal description.)
4. Location in Building. (A small scale plan of each floor is printed on the form, so that deficient components can be located simply by circling the correct area.)
5. Description of Deficiency. (A brief verbal description.)
6. Cause of Deficiency (According to the classes of obsolescence described in this report.)
7. Operation Performed. (A verbal description of the work done.)
8. Labor. (Trades, rates and hours will be noted, as well as dollar costs, so that figures can be corrected to a standard base by OCE.)
9. Materials. (Description and quantities will be noted, so that figures can be corrected to a standard base by OCE.)
10. Equipment. (Description and quantities.)
11. Recommendations. At the option of the Facilities Director, recommendations may be entered which address the problem of correcting the deficiency in question.

The Facilities Director will be left with a loose-leaf notebook containing copies of report forms to be filled in, as well as any definitions or other explanatory material which he may need.

The next visit of OCE to the Facilities Director should occur after the building has been in operation for one year. At that time the records kept by the Facilities Director will be collected, and new report forms delivered if required. The Facilities Director will be asked to comment on any aspects of maintenance and repairs which do not appear to be covered by the forms.

At the same time, the OCE representatives will apply the remaining survey techniques: physical measurement and the administration of questionnaires.

In this case the only physical measurements required will be acoustical. The noise transmission between spaces in the barracks building will be measured by acoustical technicians. They may be members of OCE who are engaged in the monitoring of acoustic performance in a large number of buildings, or they may be consultants hired as needed. Standard field testing procedures will be used to collect data such as that shown in Exhibit 3. The form includes a plan of the building, noise reduction values between selected spaces, and finally a value for average noise reduction. The recommended program of acoustical testing for each building will require about two man days of effort.

*It should be recognized that all of the forms shown are subject to further scrutiny and possible revision. They are included only for purposes of illustrating the suggested procedures.

OCE representatives should also administer questionnaires to the Facilities Director to measure the Facilities Director's subjective assessment of the building's flexibility (although it is unlikely that this questionnaire will be applicable during the early life of the building). Indeed, the question should be answered only in the light of actual experience, when alterations or additions have actually occurred. (See Exhibit 4.)

Further surveys administered during the first return visit should test the subjective assessments by the building's direct users of its acoustic qualities and of its appearance. The population of the same spaces which are measured physically for acoustic performance is given the forms shown in Exhibit 5 and Exhibit 6. Questionnaires are administered by the OCE.*

*Strenuous efforts should be made to simplify the format of all questionnaires as much as possible in order to conduct this study without the aid of specialists in survey procedures. These field surveys may of course be augmented at any time by more sophisticated survey techniques, should more precise data prove necessary.

FREQUENCY OF TESTING

Maintenance and repair cost records should be collected annually. Physical measurements of performance and surveys of user satisfaction should not be required after initial testing. Only if alterations or additions to the building occur during a year should the Facilities Director be asked to respond to the questionnaire on flexibility.

Field work by OCE personnel should therefore be limited to:

1. An initial visit of one man day to acquaint the Facilities Director with forms.

2. A first return visit with two man days devoted to acoustical testing and two man days devoted to the administration of questionnaires and the collection of cost records.

3. Further annual visits, usually limited to one man day, for consultation with the Facilities Director and collection of his records.

INTERPRETATION OF DATA

Performance data collected during the first return visit, i.e., data representing one year of use, should be compared to similar field data collected on conventional barracks buildings during the same period. Comparisons should be performed for the categories identified in Table 5: "Key Indicators of Performance for Industrialized Barracks Buildings."

1. Durability. The cost per year to maintain a satisfactory level of performance for each sub-system should be computed by the following formula:

$$(M + R) + \frac{C}{L} = P$$

where: $(M + R)$ = annual cost of maintenance and repairs*
C = replacement cost*
L = lifetime**
P = cost per year to maintain a satisfactory level of performance

Assume for example that the cost per year to maintain the performance of the exterior wall of the industrialized building is computed to be 36 cents per square foot. This figure should be compared to the performance profile of the conventional buildings tested. This comparison is illustrated in Figure 40† Similar comparisons would be plotted where possible for each of the remaining seven subsystems, as identified in Table 5. (It is likely that no costs will be incurred for maintenance and repairs on some systems, e.g., structure or roof/ceiling, until several years have elapsed.)

2. Acoustic Isolation. Noise reduction achieved by barriers in the industrialized barracks building would be compared to the acoustic performance of conventional barracks. This comparison, plotted for purposes of illustration in Figure 39, might suggest that the acoustic performance of the industrialized building is slightly superior to the average performance of conventional barracks.

Satisfaction of the building's users with its acoustic qualities would be compared to similar data from the conventional buildings (Fig. 41). In this example the slight superiority in measured performance is reflected by a slight superiority in user satisfaction.

*constant dollars

**In early years of testing, lifetime can only be estimated. The figure used should be the predicted lifetime of the building. (For example, a building classified as "semi-permanent, wood" has a lifetime or "O & M" Cost Period of 15 years.)

†The numerical values upon which the following illustrations are based are arbitrary, and are intended merely to illustrate a procedure. They are not intended to represent the actual performance levels of existing buildings.

EXHIBIT 2

(for Facilities Director)

Maintenance and Repair Report Form (pg. 1 of 2)

1. Building Description:

Installation: Fort X
Building number: 100
Building type: P(B)
Original use: EM BKS w/Mess
Current use: same
Year of construction: 1970
Major materials: steel frame, plywood panels, etc.
Method of construction: 12' x 32' modules assembled on site
Climate zone: 3
Special environmental conditions: salt spray env.

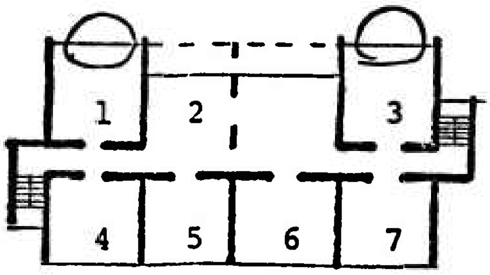
2. Sub-system Affected:

( ) structure
(X) exterior wall
( ) roof/ceiling
( ) floor/ceiling
( ) interior partitions
( ) plumbing
( ) HVAC
( ) electrical
( ) other (note):______________

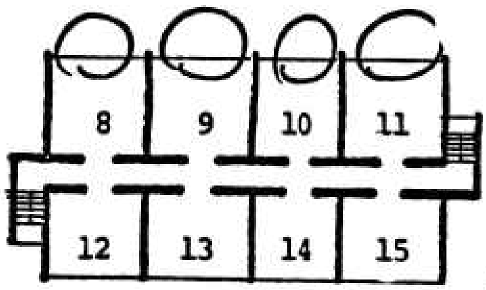
3. Deficient Component:

WINDOWS

4. Location in Building:



FIRST FLOOR PLAN



SECOND FLOOR PLAN

N

MAR report form (pg. 2 of 2)

5. Defiency: failed calking around windows

6. Cause of Defiency:

(X) physical obsolescence - (wearing out)
( ) performance obsolescence - (standards raised)
( ) task obsolescence - (change of use)
( ) esthetic obsolescence - (change of user attitudes)
( ) interface obsolescence - (dependency on other systems)
( ) other (please note): ______________________

____

7. Correction:

replaced calking as per original specs.

8. Labor:

Shop	Rate	Hours	Cost
carpentry	5.00	130	650.00

9. Materials:

Description	Cost
15 cartons of X calking	420.00

10. Equipment:

Description	Cost
none	

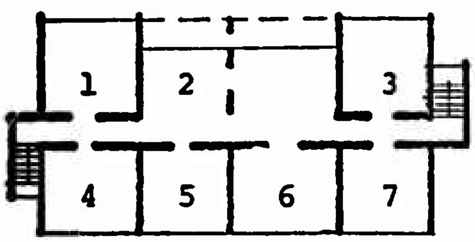
Total Cost: $1,070.00

11. Recommendations: Suggest exploring new calking compounds for these weather conditions.

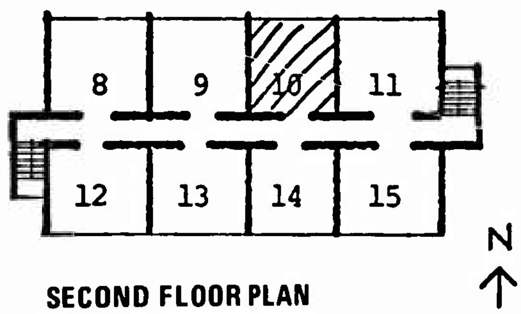
EXHIBIT 3

(for OCE testing personnel)

FIELD TEST DATA SUMMARY: ACOUSTIC ISOLATION



FIRST FLOOR PLAN



SECOND FLOOR PLAN

NOISE REDUCTION (db):

Room → Room	75–150 cps	150–300 cps	300–600 cps	600–1200 cps	1200–2400 cps	2400–4800 cps	Avg.
9 → 10	27	29	34	35	38	39	34
11 → 10	26	28	35	34	37	39	33
Corridor → 10	19	23	25	28	29	32	27
AVERAGE							$\boxed{31}$

EXHIBIT 4

(for Facilities Director)

ASSESSMENT OF FLEXIBILITY

Please check appropriate box(es).

1. ( ) Have you received requests for changes to the building.
2. ( ) Have you refused requests.
3. ( ) If (2) is checked, describe requests refused:

4. ( ) Have you been involved in adapting the building (or parts of the building) to a new use.
5. ( ) If (4) is checked, describe changes performed:

6. If (4) is checked, rate the ease with which the building or space was converted to the new use by circling one number:

easy 1 2 3 4 5 6 7 difficult

EXHIBIT 5

(for barracks users)

Please circle the number which describes your opinion best.

The quiteness of this sleeping space is:

unsatisfactory 1 2 3 4 5 6 7 satisfactory

EXHIBIT 6

(for barracks users)

Please circle the number which describes your opinion best.

The appearance of this barracks is:

unsatisfactory 1 2 3 4 5 6 7 satisfactory

3. Flexibility. It is unlikely that any responses to the questionnaire on flexibility will be available during the first few years of a building's life. This, then, will not serve as one of the early indicators of the building type's worth.

4. Appearance. Again the user's ratings of the industrialized building would be compared to rating' received by conventional buildings (Fig. 42).

At this point in the testing program it would be possible to begin to derive preliminary conclusions from the data. The conclusions would bear upon certification, testing against standards, setting of standards and problem solving in the following ways:

1. Certification. If it is assumed that the prime reasons for the use of industrialized building are to reduce first cost and speed construction, then in-use performance ought to be considered satisfactory if it meets or exceeds the performance level of existing buildings. Examining the plotted data in this hypothetical case, one sees that the performance of the industrialized building falls short of conventional buildings only in the area of appearance, as assessed by the direct users. The Army must decide whether this aspect of user satisfaction rates a high enough priority to impel corrective action.

2. Testing Against Standards. The only physical test given for which an objective standard might exist is the test for acoustic performance. In Chapter 4, "Industrialized Building: Design Compatibility" it is suggested that for Enlisted Men's barracks the sound isolation criteria of FHA Table 10.2 be met. This table states that criteria for airborne sound isolation between bedrooms and corridors, and between bedrooms and bedrooms, are set at STC 52. (The requirement is reduced to STC 48 for field tests.)

The arbitrary values for data in this example indicate that no example of conventional or industrialized building meets this standard. Since the direct users appear to find the acoustic performance of some buildings satisfactory, the standard may be unrealistically high, and should be questioned.

3. Setting of Standards. This example is largely addressed to the problem of certifying the acceptability of industrialized buildings over a relatively short period of time. The setting and refinement of standards is a long-range project. Only after years of data have been accumulated, especially on cost aspects of performance, can realistic predictions of performance begin to be made. As this becomes possible, the techniques described in PART V: "INTERPRETATION OF DATA"' can be applied.

4. Problem Solving. The survey data may uncover two classes of deficiencies in industrialized buildings.

The first possible class of deficiency is the inadequacy of whole sub-systems (such as the exterior wall in a certain class of industrialized building) or even of whole methods of construction. This class of deficiency is uncovered by analysis of the data at a gross level. In the coase of this example, no such deficiencies are revealed.

Analysis of the data at a finer level may reveal a second class of deficiency—the recurring failure of components or parts of buildings. (The failed calking noted on the sample form in Exhibit 2 is one example.) If the sample of buildings surveyed is sufficiently large and sufficiently random to represent accurately the class of buildings surveyed, the majority of recurrent deficiencies will show up in the sample.

FEEDBACK PROCEDURES

1. The OCE will act to inform the Facilities Directors at relevant installations of recommended solution to deficiencies identified in the survey process. For example, suppose a pattern emerges of the consistent failure of a particular type of calking in cold climates, especially on the weather side of the building. The correction would consist of specifying a more appropriate calking material in new construction, and replacing failed calking in existing buildings with the new material. In this case Facilities Directors in charge of buildings which utilize the deficient calking would be advised by letter to replace it (upon failure) with the recommended material.

2. The OCE will act to notify manufacturers of performance failures. These might be inadequacies of whole systems, or small details such as the calking compound mentioned above.

3. The OCE will act to certify or reject particular innovations. These might be as large as whole systems of methods of construction, or as small as details of construction or new assemblies of materials.

4. The OCE will act to propose and/or evaluate and/or revise the standards governing new construction.

CURRENT WORK IN PROBLEMS OF IN-USE APPRAISAL OF BUILDINGS

AGREMENT SYSTEMS

In the past few years, several systems for evaluating new building materials, products and systems have been put into operation in Europe. These systems are largely concerned with the certification of innovations in building. France introduced the first modern system of testing and approval more than fifteen years ago. It is operated by the Scientific and Technical Center of Building (C.S.T.B.). Great Britain (with The Agrement Board), Germany (with the Zulassung), Denmark (with a system operated by the Danish National Institute of Building Research), and the Netherlands (with a system operated by the Ratiobouw) followed. An official Union of Agrement systems (UEA) has been established.

All systems rely upon physical testing methods where possible. Tests are supplemented by the judgment of a board of technical experts who estimate from background knowledge probable performance in areas for which no testing method exists. In some cases the program of testing includes monitoring performance after an Agrement is established.

IN-USE APPRAISALS IN ENGLAND

Significant work on the appraisal of buildings in use has been going on in England for at least five years. This work addresses itself to a broader range of issues than the Agrement System, which are primarily concerned with product performance (as is the National Bureau of Standards in the U. S.). Two special areas are under intensive study: hospitals and schools.

King Edward's Hospital Fund in London (The King's Fund) has performed and published evaluations of hospitals in use (4). Its report also summarizes other work in progress in the field of hospital evaluation. An extremely detailed account has been published of the work of the Building Performance Research Unit of the University of Strathclyde in evaluating school buildings in use (5). All of this work is directed toward all three areas of performance: functional, product and cost.

Additional studies are being conducted at the boundary between architecture and psychology, which are directed toward the problem of understanding interactions between buildings and their users. Reliable methods of recording and evaluating users' attitudes are being sought (6).

IN-USE APPRAISALS IN THE UNITED STATES

Although proposals abound for the in-use appraisal of buildings, this consultant is not aware of any published studies of comprehensive scope. For example, the well-documented EFL study of acoustic performance in schools (7) is not only a lonely example of work in a field that should be crowded with entries, but it deals only with one highly circumscribed aspect of performance in one building type.

It can be expected, however, that work will pick up in this field in the near future. The Army stands to benefit greatly, and has the opportunity to confer great benefit, if it establishes contact with civilian researchers in in-use appraisal as they emerge.

CITED REFERENCES

1. Department of Defense, DOD 4270.1-M Construction Criteria Manual, Office of the Assistant Secretary of Defense (Installation and Logistics), Washington, 1968.
2. National Bureau of Standards, Report No. 8983: The Opportunity for Building Systems Innovation in the Military Construction Program of the Department of Defense, Washington, 1965.
3. Thomas A. Markus, "The Role of Building Performance Measurement and Appraisal in Design Method," The Architects' Journal, December 20, 1967, Architectural Press Ltd., London.
4. Baynes, Ken, Brian Langslow, Courtenay C. Wade, Evaluating New Hospital Buildings, King Edward's Hospital Fund, London, 1969.
5. Building Performance Research Unit, University of Strathclyde, "Building Appraisal: St. Michael's Academy, Kilwinning," The Architects' Journal, January 7, 1970, Architectural Press Ltd., London.
6. Canter, David and Roger Wolls, "A Technique for the Subjective Appraisal of Buildings," Building Science, Vol. 5, Nos. 3 & 4, December, 1970, Pergamon Press, Oxford and New York.
7. Fitzroy, Daniel and John Lyon Reid, Acoustical Environment of School Buildings, Educational Facilities Laboratory, New York, 1963.

APPENDIX G

INDUSTRIALIZED BUILDING SURVEYS
QUESTIONNAIRES

3-108A

DEPARTMENT OF THE ARMY
CONSTRUCTION ENGINEERING RESEARCH LABORATORY
P.O. BOX 4005
CHAMPAIGN, ILLINOIS 61820

March, 1971

Gentlemen:

The Corps of Engineers' Construction Engineering Research Laboratory has been commissioned by the Office of the Chief of Engineers to conduct a survey of all known systems manufacturers and builders to ascertain their capability to produce products suitable for U. S. Army installations.

Your firm has been identified as being an appropriate and important respondent to the enclosed questionnaire. If more than one questionnaire is enclosed, your firm includes several of the categories of firms we are soliciting and you need answer repetitious questions only once.

We have endeavored to keep the questions as concise and lucid as possible and wish to emphasize at the outset that *stringent precautions have been taken to preserve the confidential nature of all responses.* Individual results will not be disclosed; only statistical summaries will be released to the public.

The importance of your assistance should be emphasized, since this questionnaire will serve as a vehicle for subsequent construction procurement. A considered and timely response at the earliest possible opportunity would be mutually beneficial.

This questionnaire has been designed to be self-explanatory. *Most of the questions can be answered by circling a single code number.* The questions requiring written answers have been kept to a minimum. Should any questions of interpretation or content arise, please feel free to contact me, or Dr. R. M. Dinnat of CERL's staff by calling *collect* to 217-352-6511.

Thank you for your cooperation and participation. Statistical results of this survey will be furnished to all respondents.

Sincerely yours,

D. Gordon Bagby

DR. D. GORDON BAGBY
Principal Investigator
Special Projects Branch

3-109

TYPE 1 1
QUESTIONNAIRE____ 2-4
STUDY A051 5-8

SURVEY OF INDUSTRIALIZED BUILDING SYSTEMS

CATEGORY ONE - SUPPLIER/MANUFACTURER

Definition:

For the purpose of this questionnaire, the Industrialized Building Project will be defined as one in which the component parts are co-ordinated and have the characteristic of being industrially mass produced and assembled either in the factory or at the site prior to erection.

FIRM NAME ______________________________

ADDRESS ______________________________

PRODUCT NAME(S) ______________________________

____

____

____

If you have more than one permanent production facility, please list the locations below:

a. ______________________________

b. ______________________________

c. ______________________________

NAME OF PERSON COMPLETING QUESTIONNAIRE

____

TITLE: ______________________________

TELEPHONE NUMBER ______________________________

(Please circle one answer code for each question unless otherwise instructed)

1. Which of the following services does your firm provide?

Product engineering	1	9-13/9
Manufacture	2	
Design	3	
Planning	4	
Erection	5	

2. What is the state of development of your product?

Conceptual stage	1	14,15/9
Prototype erected	2	
Ready for production	3	
In production	4	

3. What was the year of first U. S. production of your component or system?

Not in production	1	16/9
Production prior to 1963	2	
1963	3	
1964	4	
1965	5	
1966	6	
1967	7	
1968	8	
1969	9	
1970	0	

4. Do you contemplate building additional production facilities within the next:

	Yes	No	
A. year?	1	2	17/9
B. 3 years?	1	2	
C. 5 years?	1	2	

5. Assume your firm is not in production and no inventory is available. What would be the normal period of time between approval of shop drawings and the availability of your finished produce for a particular project?

	Less Than 4 wks	5-7 wks	8-10 wks	11-13 wks	14-16 wks	17 or more wks	Evaluation not possible	
A. Standard product	1	2	3	4	5	6	7	18-20/9
B. Product altered significantly in dim.	1	2	3	4	5	6	7	
C. Product altered significantly in material property	1	2	3	4	5	6	7	

6. Who may buy your product?

Sell directly to owner of building (client) 1 21-24/9
Sell to any builder/developer 2
Sell to franchised dealer/erector 3
Produce for company use only 4

7. Which methods of specification have been used to procure your product?

Performance requirements 1 25-29/9
Definitive specifications 2
Reference to your product by name 3
Product selected by architect - no competition 4
Other 5

8. Please mark the number codes under the appropriate column headings for each type of procurement shown.

	Only method will use	Prefer this method	Have used this method	Am willing to use it	Not appropriate Would not bid	Not familiar with method	
A. Unilateral Price Determination - Price established by your firm under a competitive situation -	1	2	3	4	5	6	30-35/9
B. Bilateral Price Determination - Price established by mutual agreement between firm and client (negotiation).	1	2	3	4	5	6	
C. Ultimate Cost (Life Cycle) Award based on future costs as well as initial (insur., maint., tax, replacement).	1	2	3	4	5	6	
D. Two Step Bidding - Advertisement limited to acceptable technical proposals - award to low bidder.	1	2	3	4	5	6	
E. Turnkey - Construction according to approved specifications.	1	2	3	4	5	6	
F. Catalogue or "Bush" Type Contract.	1	2	3	4	5	6	

9. a. Circle all services provided by your firm.

Architecture	1	36-41/9
Engineering	2	
General Contracting . . .	3	
Subcontracting	4	
Manufacture/Supply building products	5	
Construction Management .	6	

b. If your firm will not contract directly with the building owner, circle all parties with whom your firm will contract.

Architect	1	42-48/9
Engineer	2	
General Contractor . . .	3	
Subcontractor	4	
Manufacturer/Supplier of building products	5	
Construction Manager . .	6	

10. What dollar market volume would you require over a two year period to justify the expenditure of research and development funds to design and bid specific systems applicable solely to U. S. Army facilities such as:

	$500,000-1,000,000	$ 2-3 million	$ 4-6 million	$ 7-10 million	
A. Barracks . . . . . . $	1	2	3	4	49-54/9
B. Bachelor Officer Quarters	1	2	3	4	
C. Administrative buildings	1	2	3	4	
D. Maintenance shops . $	1	2	3	4	
E. Classroom-type training facilities . . . . . $	1	2	3	4	
F. Storage buildings . $	1	2	3	4	

11. Are there any restrictive criteria within DOD Manual of Construction which affect your ability to supply components, sub-systems or systems?

Yes	No	Don't know	
1	2	3	55/9

12. Have your components and subsystems been employed in the construction of any facilities governed by the following authoritatives?

56-61/9

FHA - Minimum Property Standards 1
Veterans Administration 2
U. S. Navy 3
U. S. Air Force 4
U. S. Army Corps of Engineers . 5
Other 6

13. Below are found four categories of product output. Please indicate the minimum output of industrialized products within one or more of the appropriate categories to justify a production run by your firm for a particular project. If you have more than one plant, indicate amount necessary from one plant only.

CATEGORY A Dollar Volume	CATEGORY B No. Product Units	
Less than $500,000. . . 1	0 to 99 1	62-65/9
$500,000 to 1 million . 2	100 to 249 2	
1 million to 2 3	250 - 499 3	
2 million to 3 4	500 to 999 4	
3 million to 4 5	1000 to 2000 5	
more than 5 million . . 6	greater than 2000 . . 6	

	CATEGORY C Sq. Ft. of Product	CATEGORY D Sq. Ft. of Building
50,000 or less	 1	1
50,000 to 100,000	 2	2
100,000 to 200,000	 3	3
200,000 to 500,000	 4	4
500,000 to 1,000,000	 5	5
1,000,000 or more	 6	6

14. We are interested in the capabilities of industry to meet Department of Defense installation needs. To assist us in this effort, please indicate your firm's 1970 level of output of Industrialized products within one or more appropriate categories.

CATEGORY A Dollar Volume	CATEGORY B No. Product Units	
less than 1 million . . 1	0 to 99 1	66-69/9
1 million to 3 2	100 to 250 2	
3 million to 5 3	250 to 500 3	
5 million to 10 4	500 to 1,000 4	
10 million to 20 5	1,000 to 5,000 . . . 5	
more than 20 million . .6	more than 5,000 . . . 6	

	CATEGORY C Sq. Ft. Product	CATEGORY D Sq. Ft. Building
50,000 or less	 1	 1
50,000 to 100,000	 2	 2
100,000 to 200,000	 3	 3
200,000 to 500,000	 4	 4
500,000 to 1,000,000	 5	 5
1,000,000 or more	 6	 6
Not in production at present	. . . . . .	 7

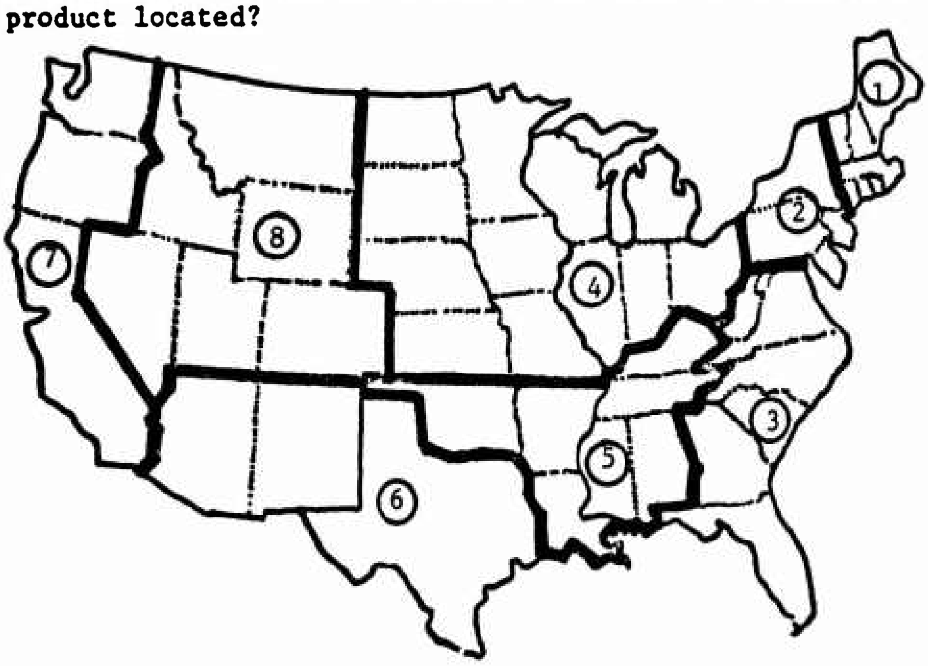
15. If you have a moveable plant, what is the greatest distance between the home office and a completed project utilizing your components or products:

49 miles or less	1	70/9
50 - 99	2	
100 - 149	3	
150 - 299	4	
300 - 499	5	
500 or more	6	

16. How many franchisers, if any, produce your product?

0	1	71/9
1	2	
2 - 4	3	
5 - 9	4	
10 or more	5	

17. In what areas of the U. S. are franchisers who have produced your product located?



72-79/9

NE	1	80/1
Mid Atlantic	2	
SE	3	
No. Central	4	
So. Central	5	
SW	6	
Pacific	7	
Mountain	8	

18. What affiliation does your firm have with other companies producing materials utilized in your product?

Total production by your firm	1	9-11/9
Assemble components manufactured by other companies .	2	
Fabricate components from processed materials	3	

19. Which climatic conditions act as constraints on your product?

Freezing weather during site manufacture	1	12-15/9
Freezing weather during erection	2	
Precipitation during erection	3	
Excessive depth of frost line	4	

20. In which form is your product delivered to the site?

Structurally complete units	1	16,17/9
Knock down for site assembly	2	
Site manufacture	3	

21. What pieces of major equipment are normally required for erection of your product at the site?

Tower crane, building mounted	1	18-21/9
Mobile crane exceeding building height	2	
Tractor/trailer	3	
Special equipment not generally available	4	

22. What is the greatest distance between your plant (or any one of your permanent plants) and a completed project utilizing your products produced in that plant?

less than 50	1	22/9
50 - 99	2	
100 - 249	3	
250 - 499	4	
500 or more	5	

23. What is the greatest distance you feel you could go between your plant and project and remain competitive with conventional construction?

		23/9
50 - 99	1	
100 - 249	2	
250 - 500	3	
500 or more	4	

24. What was the average number of employees engaged in industrialized products manufactured in your firm during the following periods?

A. June, Jul., Aug., Sept.		B. Dec., Jan., Feb.	
0 - 10	1	 1	24,25/9
11 - 25	2	 2	
26 - 50	3	 3	
51 - 100	4	 4	
101 - 250	5	 5	
251 - 500	6	 6	
Greater than 500	7	 7	

25. Do you have life cycle or maintenance and operating cost information for either completed projects or as estimated costs?

Yes 1 26/9
No 2

26. Based on the approximate degrees of alteration indicated, determine the effect of making each of the following changes in your product:

	Standard product not alterable Complete retooling necessary	Some difficulty with alteration	Easily Accomodated with standard product	Many variable models available	Insufficient data - evaluation of effect not possible	
A. Alteration of dimension	1	2	3	4	5	27-29/9
B. Alteration of material properties.	1	2	3	4	5	
C. Alteration of config. of building	1	2	3	4	5	

27. Are there any existing patent or copyright restrictions on the use of your product?

Yes	1	30/9
No	2	

If yes, describe ____

____

____

28. Into which one of the following major categories does your subsystem most nearly fall?

Structure	1	31/9
Enclosing exterior walls . .	2	
Interior partitions	3	
Ceilings	4	
HVAC	5	
Electrical	6	

29. Assuming modular planning restraints, with which of the following major categories have you, or can you, interface?

Structure	1	32-37/9
Enclosing exterior walls . .	2	
Interior partitions	3	
Ceilings	4	
HVAC	5	
Electrical	6	

30. Indicate which of the following codes or standards your product meets.

BOCA Basic Building Code	01	38-48/9
Uniform Building Code	02	
National Building Code	03	
Southern Standard Building Code	04	
Underwriters Laboratories	05	
American Society for Testing and Materials	06	
National Electrical Code	07	
National Plumbing Code	08	
American Concrete Institute	09	
National Fire Protection Association	10	
American National Standards Institute	11	

EXPERIENCE SECTION

31. Please list ten Industrialized Building projects in which your product has been installed, including your first project and most recent project. If less than ten, please list all projects.

PROJECT NAME: ______________________________

LOCATION: ______________________________

BUILDING OWNER: ______________________________

DATE COMPLETED: ______________________________

PROJECT NAME: ______________________________

LOCATION: ______________________________

BUILDING OWNER: ______________________________

DATE COMPLETED: ______________________________

PROJECT NAME: ______________________________

LOCATION: ______________________________

BUILDING OWNER: ______________________________

DATE COMPLETED: ______________________________

PROJECT NAME: ______________________________

LOCATION: ______________________________

BUILDING OWNER: ______________________________

DATE COMPLETED: ______________________________

31. (Continued)

PROJECT NAME: ______________________________

LOCATION: ______________________________

BUILDING OWNER: ______________________________

DATE COMPLETED: ______________________________

PROJECT NAME: ______________________________

LOCATION: ______________________________

BUILDING OWNER: ______________________________

DATE COMPLETED: ______________________________

PROJECT NAME: ______________________________

LOCATION: ______________________________

BUILDING OWNER: ______________________________

DATE COMPLETED: ______________________________

PROJECT NAME: ______________________________

LOCATION: ______________________________

BUILDING OWNER: ______________________________

DATE COMPLETED: ______________________________

PROJECT NAME: ______________________________

LOCATION: ______________________________

BUILDING OWNER: ______________________________

DATE COMPLETED: ______________________________

31. (Continued)

PROJECT .'^ME: ______________________________

LOCATIO ______________________________

BUILDING uWNER: ______________________________

DATE COMPLETED: ______________________________

GENERAL REMARKS: ______________________________

____

____

____

____

____

Below you will find a list of major building components and/or subsystems. Please encircle the appropriate answer and then turn to the sections of the questionnaire corresponding to the subsystems and components you have indicated.

32. Which of the following major building components and/or subsystems are customarily provided by your firm?

Foundations	01	49-59/9
Vertical and/or horizontal structure	02	
Structural modules	03	
Interior stairways	04	
Enclosing exterior walls	05	
Roofing systems	06	
Interior partitions and doors	07	
Ceilings	08	
Floor finishes	09	
Heating, ventilating and air conditioning	10	
Electrical	11	

FOUNDATION SECTION

33. Do you customarily, or prefer to, provide foundations?

Yes	1	60/9
No	2	

34. If "yes" to above, is any part of the foundation system pre-manufactured on- or off-site?

Yes	1	61/9
No	2	

35. Which of the following types are appropriate for your sub-system(s)?

Concrete spread footings	1	62-66/9
Caissons or piles	2	
Poured concrete walls	3	
Concrete block walls	4	
Piers and grade beams	5	

36. What do you customarily provide, or prefer, for the floor at or near grade level?

Concrete slab on ground	1	67-70/9
Pre-cast concrete, suspended	2	
Other suspended type	3	
Other	4	

STRUCTURE SECTION

37. Within which of the following story ranges has your project been built?

1 story	1	71-76/9
2 - 3 stories	2	
4 - 8 stories	3	
9 - 15 stories	4	
16 - 25 stories	5	
over 25 stories	6	

77-79
80-2

The following questions all refer to building three stories or less in height. (If your project is not normally built within these limits, answer questions assuming that the building height is the lowest category you have checked in Question 37)

38. Does your subsystem meet or exceed the following:

	Yes	No	Don't Know	
a. Live load-roof 20 psf	1	2	3	9,10/9
b. Live load-roof 40 psf	1	2	3	
Live Load-Suspended Floors				
c. Residential 40 psf	1	2	3	11-14/9
d. Office 80 psf	1	2	3	
e. Classroom 60 psf	1	2	3	
f. Public area 100 psf	1	2	3	
Seismic Design (Uniform Building Code)				
g. Zone 0	1	2	3	15-18/9
h. Zone 1	1	2	3	
i. Zone 2	1	2	3	
j. Zone 3	1	2	3	
Wind Load - not less than:				
k. 20 psf	1	2	3	19/9
l. 30 psf	1	2	3	
m. 40 psf	1	2	3	
n. 50 psf	1	2	3	

39. Which of the following construction classifications, as defined by the National Building Code, will permit the use of your subsystem as a part of a Code-acceptable assembly?

Fire-resistive, Type B	1	20-25/9
Protected non-combustible	2	
Unprotected non-combustible	3	
Heavy timber	4	
Wood frame	5	
Ordinary	6	

VERTICAL STRUCTURE SECTION

40. What is the predominant material?

Masonry	1	26/9
Wood	2	
Structural steel	3	
Pre-cast concrete	4	
Cast-in-place concrete	5	
Other	6	

41. Which of the following most nearly describes your vertical structure?

Bearing wall	1	27/9
Post-and-beam	2	
Pre-assembled panel	3	
Other combination	4	

HORIZONTAL STRUCTURE SECTION

42. What is the predominant material employed for the primary and secondary members?

Structural steel - Rolled and/or open-web members . . .	1	28/9
Pre-cast concrete	2	
Cast-in-place concrete	3	
Wood	4	
Other	5	

43. What is the predominant material employed for the floor and roof decks?

	Floor	Roof	
Metal	1	2	29,30/9
Metal with cast-in-place fill	1	2	
Pre-cast gypsum	1	2	
Poured-in-place gypsum	1	2	
Pre-cast concrete	1	2	
Cast-in-place concrete	1	2	
Wood	1	2	
Pre-manufactured panels other than above	1	2	

44. What is the limiting clear span of the subsystem as customarily produced (for uniform live loads less than 50 psf)?

Not more than 12 feet	1	31/9
12 to 16 feet	2	
16 to 24 feet	3	
24 to 30 feet	4	
30 to 36 feet	5	
Over 36 feet	6	

45. Which of the following most nearly describes the production technique used in completing this subsystem for use in a building project?

Traditional assembly of components at site	1	32/9
50% shop-assembled at site, 50% conventional erection .	2	
50% factory-assembly, transported, 50% field erection .	3	
90% shop-assembled at site, 10% conventional erection .	4	
90% factory-assembled, transported, 10% field election,	5	

46. Does your subsystem meet or exceed the following vertical, live load deflection limitations?

A.	1/240 span	1	33/9
	1/360 span	2	
B.	Depth/span ratio less than 1/20	1	34/9
	Depth/span ratio less than 1/25	2	
	Depth/span ratio less than 1/30	3	

47. Do the primary and secondary members allow for horizontal penetration by other subsystems?

Branch ductwork, piping and conduit readily	1	35-39/9
Small piping and conduit readily	2	
Ductwork requires special provisions	3	
Optimum use of subsystem permits penetration in one direction	4	
Optimum use of subsystem does not permit penetration . .	5	

STRUCTURAL MODULES

For purposes of this questionnaire, a "structural module" is defined as a geometric shape providing vertical and horizontal enclosure for a habitable volume approximately ten feet by eight feet (clear) height, factory-produced and transported to the project site.

48. Which of the following floor areas does each module provide?

Less than 100 sq. ft.	1	40/9
100 - 199 sq. ft.	2	
200 - 399 sq. ft.	3	
Greater than 400 sq. ft.	4	

49. Is each module self-supporting?

Yes	1	41/9
No.	2	

50. Does it depend in part on adjacent modules?

Yes	1	42/9
No.	2	

51. Can modules be stacked vertically without additional support?

Two modules high?	1	43,44/9
Three modules high?	2	

52. Are modules customarily abutted, forming a larger building?

Yes. . . .	1	45/9
No	2	

	Yes	No	
53. Are modules customarily abutted, forming a longer building?	1	2	46/9

54. If available as dwelling units, which of the following best describes the completion status of your module when delivered to the job site.

	On-Site Work Required	Self-Contained or Complete	
Plumbing	1	2	47/9
HVAC Provisions	1	2	48/9
Wiring and Lighting	1	2	49/9
Structural Shell	1	2	50/9
Exterior	1	2	51/9
Interior	1	2	52/9

INTERIOR STAIRWAYS

55. Which of the following best describes your subsystem?

Factory-Mfd. forms for cast-in-place concrete	1	53/9
Metal supports, cast-in-place treads & platforms. . . .	2	
Metal supports, factory-mfd. treads & platforms	3	
Factroy-Mfd. wood throughout.	4	
Factory-Mfd. construction throughout.	5	
Other	6	

56. Does your subsystem meet or exceed the requirements of the National Building Code with respect to the following?

	Yes	No	
			54-56/9
Design live load.	1	2	
Units of exit width	1	2	
Dimensions of intermediate & floor landings .	1	2	

57. Does your subsystem customarily include code-required handrails? . . . . 1 2 — 57/9

58. Do you customarily, or prefer to, provide the following:

Non-slip treads and/or nosings.	1	2	58-61/9
Factory-applied prime coatings.	1	2	
Factory-applied finish coatings	1	2	
Floor landings.	1	2	

59. If your subsystem requires field-assembly and/or installation, what is the customary/required method?

		62/9
Welding.	1	
Bolting.	2	
Other.	3	

ENCLOSING EXTERIOR WALLS

60. What is the predominant material/construction type, excluding glass, which best characterizes your subsystem?

Masonry	1	63/9
Steel	2	
Aluminum.	3	
Wood.	4	
Pre-Cast Concrete	5	
Cement-Asbestos	6	
Plastic	7	
Other_______________	8	

61. Which of the following best describes the composition of your subsystem (excluding glazed openings)?

	Exterior	Core	Interior	64-66/9
Masonry	1	2	3	
Steel	1	2	3	
Aluminum, Factory-coated. .	1	2	3	
Aluminum, anodized.	1	2	3	
Pre-cast concrete	1	2	3	
Wood, unfinished or field-painted.	1	2	3	
Wood, pre-finished.	1	2	3	
Cement-asbestos	1	2	3	
Hardboard, pre-finished . .	1	2	3	
Gypsum Board, unfinished or field painted.	1	2	3	
Vinyl wall-covering	1	2	3	
Ceramic tile.	1	2	3	
Plastic	1	2	3	
Other_________________ . .	1	2	3	

62. Which of the following opening components does your subsystem customarily include?

Windows - fixed glass	1	67-74/9
Windows - operable.	2	
Sliding, glazed doors	3	
Hinged doors.	4	
Louvered openings	5	
Solar screens	6	
Overhead-type doors	7	
UL-labeled doors, hinged.	8	

63. Which of the following window frame material/finishes does your subsystem customarily include:

Aluminum, Mill finish	1	75-79/9
Aluminum, factory-coated or clad.	2	
Aluminum, anodized.	3	
Steel, factory-finished	4	
Steel, field painted.	5	
Wood, factory-painted or clad	6	
Wood, field-painted	7	

64. With respect to glazed openings, which of the following best apply to your subsystem (encircle only one number in each row)? 80-3

		Customary	Available Option	Not Available	
A.	No restriction on ratio of glazed vs. opaque area	1	2	3	9/9
B.	Insect screens. . . .	1	2	3	10/9
C.	Factory-glazed. . . .	1	2	3	11/9
D.	Sheet glass	1	2	3	12/9
E.	Plate glass	1	2	3	13/9
F.	Insulating glass. . .	1	2	3	14/9
G.	Heat absorbing/glare reducing glass. . .	1	2	3	15/9
H.	Plastic Glazing . . .	1	2	3	16/9
I.	Storm Windows	1	2	3	17/9

65. Assuming a single or repetitive building project at a specific site, with total construction costs of not less than $500,000.00, what constraints affect the appearance factors if optimum subsystem costs are realized, as follows (encircle only one number in each row)?

		2 Choices	4 Choices	10 or more choices	
A.	Opaque wall-exterior-color	1	2	3	18/9
B.	Opaque wall-interior-color	1	2	3	19/9
C.	Glazed opening frames color. . . .	1	2	3	20/9
D.	Opaque wall-texture/configuration . . .	1	2	3	21/9

66. Does your subsystem meet or exceed the following criteria?

A. Thermal conductivity (of total assembly of solid panel portions of wall)

"U" less than 0.10 . . . . 1 — 22/9
"U" less than 0.15 2
"U" less than 0.27 3
"U" 0.27 or greater. 4

B. Fire resistance, when tested in accordance with ASTM E-119; rated:

More than 2-hour . . . . 1 — 23/9
2-hour 2
1-hour 3
30-minute non-combustible. 4
No recognized test data available. 5

C. Fire Safety (interior surfaces) when tested in accordance with ASTM E84-68:

Fuel Contribution: 5. . . . . 1 — 24/9
Flame Spread: 75. . . . . 2 — 25/9
Smoke Developed: 50 . . . . 3 — 26/9
Don't Know . . . . 4 — 27/9

D. Water penetration:

None, except minimal controlled amount, tested in accordance with NAAMM Standard TM-1-68T . . . . 1 — 28/9
Don't know. 2

E. Air infiltration:

Not in excess of 0.06 CFM/hour/sq. ft. of wall area, tested in accordance with NAAMM Standard TM-1-68T . . . 1 — 29/9
Don't know. 2

ROOFING SYSTEM SECTION

67. Which of the following best describes your subsystem?

Shingles (wood, asbestos, clay tile) . . . . 1 — 30/9
Metal (aluminum, tin, teyline, zinc, copper) 2
Mineral-surfaced roll roofing 3
Built-up, multi-ply, pitch or asphalt, stone- 4
surface
One-ply, applied sheet 5
One-ply, spray-applied 6
Other 7

68. Which of the following types do you customarily, or prefer to provide to augment the thermal insulation of your standard product.

Batt, sprayed or blown, below roof deck . . . . 1 — 31-35/9
Rigid or semi-rigid, vegetable or wood fibrous 2
Rigid or semi-regid, inorganic 3
Cementitious, cast-in-place 4
Foamed-in-place 5

69. How do you evaluate the effects of temperature and weather conditions during the application of your subsystem?

Little or no effect . . . . 1 — 36/9
Best results during April thru October 2
Requires ideal conditions 3

70. Can your subsystem meet or exceed the following?

		Yes	No	Don't Know	
A.	Thermal ("U") factor of not less than 0.15-0.10 (excluding structural roof deck)	1	2	3	37/9
B.	Classification A in accordance with Underwriters Laboratories, Inc.	1	2	3	38/9
C.	Classification B in accordance with U.L.	1	2	3	39/9
D.	Classification C in accordance with U. L.	1	2	3	40/9

71. Which of the following guarantees do you customarily provide to the owner?

Traditional, one year from date of completion 1 41-45/9
Written applicator's guarantee, 2 years or more . . . 2
Manufacturers traditional bond, total dollar limit. . .3
Bonded guarantee, fewer exclusions than above 4
Other 5

INTERIOR PARTITIONS SECTION

72. Which of the following best describes assemblies employed in your subsystem?

Wood studs, gypsum board faces	1	46/9
Metal studs, or channels, gypsum board faces	2	
Gypsum board faces laminated to coreboard	3	
Metal-faced sandwich construction	4	
Masonry	5	
Other	6	

73. Which of the following finishes are offered as options for your subsystem?

Field-painting	1	47-51/9
Factory-baked enamel	2	
Ceramic tile	3	
Vinyl wall covering	4	
Pre-finished hardboard	5	
Other	6	

74. Which of the following best characterizes the flexibility characteristics of your subsystem?

Movable	1	52/9
Demountable (relocatable with 90% salvage)	2	
Supports only salvageable if relocated	3	

	Yes	No	
75. Does your subsystem readily permit wiring for switches and receptacles?	1	2	53/9
76. Does your subsystem customarily include doors and frames?	1	2	54/9

77. If "Yes" above, which of the following do you supply?

Metal frames	1	55-62/9
Wood frames	2	
Plastic frames	3	
Hollow-core doors	4	
Solid-core doors	5	
Wood faces	6	
Hardboard faces	7	
Other faces	8	

78. Can you provide the following labeled doors and frames when required, per UL requirements?

	Yes	No	
			63/9
Interior, Class B	1	2	64/9
Interior, Class C	1	2	

79. Which of the following general characteristics customarily apply?

	Yes	No	
Doors are factory-finished	1	2	65/9
Frames are factory-finished	1	2	66/9
Doors are pre-hung at factory	1	2	67/9
Doors and frames are factory-prepared for field-installed hardware . .	1	2	68/9
Finish hardware is factory-installed	1	2	69/9

80. Does your interior partition sybsystem meet or exceed the following performance criteria?

		Yes	No	Don't Know	
A.	Sound Transmission:				
	Between similar occupancies (e.g. office-to-office, dwelling unit-to-dwelling unit) STC rating not less than 45, per ASTM E90-667.	1	2	3	70/9
	Between private-public areas (e.g. office-to-toliet room, dwelling unit-to-corridor) STC rating not less than 50.	1	2	3	71/9
	Doors between private-public areas, STC rating not less than 24.	1	2	3	72/9
B.	Fire Resistance, per ASTM E119-69:				
	Non-combustible	1	2	3	73/9
	1-hour rated	1	2	3	74/9
	2-hour rated	1	2	3	75/9
C.	Flame Spread Test per ASTM E84-68:				
	Flame spread not greater than 75	1	2	3	76/9
	Smoke developed not greater than 50	1	2	3	77/9
D.	Structural:				
	Will pass impact load test, per ASTM E72-68, performed on door and solid partition 9 feet high.	1	2	3	78/9
	Will resist lateral live load of 5 psf	1	2	3	79/9

CEILINGS SECTION

81. Which of the following best describe assemblies employed in your available subsystem?

Gypsum board, applied directly to structure	1	9-14/9
Gypsum board, applied to wood nailers	2	
Gypsum board, applied to metal furring	3	
Gypsum board, suspension system	4	
Mineral tile, applied directly to structure	5	
Mineral tile, suspension system	6	
Integrated lighting-ceiling system	7	
Integrated lighting-ceiling system with built-in . . . air diffuser tracks	8	
Other	9	

82. Which of the following finishes are offered as options for your subsystem?

Field-painting	1	15-19/9
Factory-finished	2	
Vinyl-covered	3	
Factory-baked enamel	4	
Other	5	

83. Does ceiling system provide lateral support for partition system?

Yes	No	
1	2	20/9

84. Does ceiling system show flexibility of location for partitions?

Yes	No	
1	2	21/9

85. Does ceiling or lighting-ceiling system provide for access in each 25 sq. ft. for purposes of relocating air distribution ducts and electrical distribution?

Yes	No	
1	2	22/9

86. Has lighting-ceiling system been designed to inter-relate with:

Fire protection system	1	23-27/9
Structural system	2	
HVAC system	3	
Partition system	4	
Plumbing system	5	

87 Does lighting-ceiling system include:

Acoustical control	1	28-33/9
Fireproofing	2	
Air handling openings for supply and return air. . . . as required by HVAC system	3	
Provisions for support of movable partitions	4	
Provisions for concealed communication system . . . . . speakers	5	
Provisions for automatic sprinkler heads	6	

88. What is basic module of lighting-ceiling system:

1'-0"	1	34/9
2'-0"	2	
2'-6"	3	
4'-0"	4	
5'-0"	5	
Other	6	

89. Using your floor and roof construction assemblies, what fire ratings (using ASTM E-119 Test) can be achieved with the ceiling or lighting-ceiling system?

	Ceiling System	Lighting-Ceiling System	
None	1	1	35,36/9
1/2 Hour	2	2	
One hour	3	3	
One and one-half hours . .	4	4	
Two hours	5	5	
Three hours	6	6	
Four hours	7	7	
Don't know	8	8	

FLOOR FINISHES SECTION

90. Which of the following does your subsystem provide:

	Standard	Readily Available Option	Special Order	
Carpeting with separate cushion .	1	2	3	37/9
Carpeting with integral cushion	1	2	3	38/9
Asphalt tile	1	2	3	39/9
Vinyl-asbestos tile	1	2	3	40/9
Vinyl sheet	1	2	3	41/9
Vinyl sheet with foam back . . .	1	2	3	42/9
Ceramic tile	1	2	3	43/9
Terrazzo	1	2	3	44/9
Wood (block or strip)	1	2	3	45/9
Seamless	1	2	3	46/9
Marble, slate or stone	1	2	3	47/9
Other	1	2	3	48/9

91. Assuming a building project requiring 500 sq. ft. of a given floor covering, installed repetitively (e.g. dwelling units), how many color/pattern choices are permissable without affecting optimum subsystem cost?

1 Choice	1	49/9
2 Choices	2	
3 Choices	3	
4 Choices or more	4	

HEATING, VENTILATION AND AIR CONDITIONING SECTION

92. What energy conversion systems employed for heating:

Warm air	1	50-53/9
Hot water	2	
Steam	3	
Electric radiation	4	

93. Does ventilation system provide:

	Yes	No	
Supply	1	2	54/9
Exhaust	1	2	55/9

94. Is air conditioning:

	Yes	No	
Integral with ventilation system	1	2	56/9
Independent of ventilation system	1	2	57/9
Combined with heating system	1	2	58/9

95. Is HVAC system:

	Yes	No	
Compatible with structural ceiling system . .	1	2	59/9
Capable of providing controlled zones	1	2	60/9
Adaptable to zone changes	1	2	61/9
Designed in accordance with ASHRAE stds.. . .	1	2	62/9
Dependent on plenum supply or return	1	2	63/9

96. What is minimum size of control zones for HVAC system?

0-400 sq. ft.	1	64/9
400-600 sq. ft.	2	
600-800 sq. ft.	3	
800-1000 sq. ft.	4	
1000 sq. ft. and over	5	

97. Using ASTM E-90-66T Tests can noise level be held to below:

	Yes	No	Don't Know	
NC-30	1	2	3	65/9
NC-35	1	2	3	66/9
NC-40	1	2	3	67/9

98. Can you furnish operating and maintenance cost analysis of total HVAC system?

Yes	No	
1	2	68/9

ELECTRICAL SECTION

99. Does your subsystem conform to the requirements of the following authorities?

	Yes	No	Partially	Don't Know	
National Electrical Code (NEC)	1	2	3	4	69/9
National Electrical Manufacturers Association (NEMA)	1	2	3	4	70/9
Underwriters' Laboratories, Inc. (UL)	1	2	3	4	71/9

100. Which of the following components are customarily included as part of your subsystem?

Transformers	1	72-76/9
Main Switchgear	2	
Distribution Panels	3	
Lighting Panels	4	
Feeders	5	
Switches and Receptacles . .	6	
Lighting Features	7	
Lighting - Ceiling	8	
Fire Alarm System	9	
Communications and P.A. Systems	0	

101. Which of the following distribution methods does your subsystem customarily employ?

Rigid Conduit	1	77/9
Flexible Conduit	2	
Romex Shielded Cable	3	

102. Assuming that a project employs a horizontal structural or structural module subsystem, which is shop-assembled, estimate the percentage of your electrical subsystem which is installed in the plant or shop:

Less than 10%	1	73/9
10 to 30%	2	
30 to 50%	3	
Over 50%	4	

103. Does the method of attaching receptacles allow for relocation?

Yes	1	79/9
No	2	

DEPARTMENT OF THE ARMY
CONSTRUCTION ENGINEERING RESEARCH LABORATORY
P.O. BOX 4005
CHAMPAIGN, ILLINOIS 61820

CERL-DS

April 1971

Gentlemen:

Thank you for participating in our Survey of Industrialized Building Systems.

As a continuation of the effort to investigate the feasibility of using industrialized building on U. S. Military installations, we are seeking building construction cost data for completed industrialized projects. We have selected one or two appropriate industrialized projects from each of several significant members of the industry, your firm being one of those so identified. Each project selected from those completed by your firm is indicated at the top of the one-page cost-data form which we are asking you to complete. The cost-data form is on the reverse side of this letter. If two of your projects have been selected, an additional cost-data form is attached.

Fully realizing the highly confidential nature of this information, we assure you that in no way will any specific project be identified with its cost data, and that only statistical summaries will be released to the public. Furthermore, the data received from you will in no way be used to judge your firm or products, therefore we are confident that the data will possess the accuracy necessary for us to make an appropriate evaluation of the current state of the industrialized building industry.

It is hoped that you are able to make this last and critical contribution. All responses should be received by us no later than May 3, 1971. Should any questions arise, please feel free to contact me, or Dr. D. Gordon Bagby of CERL's staff by calling collect to 217-352-6511. Thank you for your participation.

Sincerely,

RM Dinnat

DR. R. M. DINNAT
Acting Chief, Special Projects Branch

3-144A

BUILDING CONSTRUCTION COST DATA - INDUSTRIALIZED PROJECTS

Project ______________________________ Occupancy Type ______________
Location ______________________________ Const Time ______________ Mos.
Bid Date: Year _____ Quarter: Apr- M-J ____ Jul- A-S___ Oct- N-D ___ Jan- F-M ___

BLDG. DESCRIPTION AND MATERIALS Please check the appropriate boxes.

BLDG FORM
☐Rectangular
☐Irregular
☐Polygonal
☐Curved

PARKING
☐Surface exterior
☐In bldg.

SITE TOPOGRAPHY
☐Flat
☐Mod. grade
☐Heavy grade

FOUNDATION
☐Piling
☐Cassions
☐Spread footings
☐Wall footings

VERTICAL STRUCTURE
☐Steel frame
☐Conc. encased steel
☐Concrete frame
☐Concrete wall bearing
☐Masonry wall bearing
☐Wood

HORIZONTAL STRUCTURE
☐Concrete cast in place
☐Concrete precast
☐Cellular steel, conc. fill
☐Barjoists, slab
☐Cement fiber plank
☐Poured gypsum
☐Wood
☐Other ______________

CONVEYING SYSTEMS
☐Elevators, no. ______
☐Escalators, no. _____
☐Crane

EXTERIOR WALLS
☐Masonry
☐Steel
☐Concrete cast in place
☐Concrete precast
☐Plastic
☐Wood
☐Sandwich

INTERIOR PARTITIONS
☐Concrete
☐Masonry
☐Metal stud
☐Wood stud
☐Sandwich

GEN. BLDG. FINISH QUALITY
☐Austere
☐Average
☐Luxury

PLUMBING
☐Fire sprinkler
☐Laboratories
☐Bathroom modules
☐Conventional

MECHANICAL, HEATING
☐Steam
☐Hot water
☐Warm air
☐Electric

MECHANICAL, COOLING
☐Duct system
☐Fan coils
☐Heat pumps

BUILDING DIMENSION

Height ______________ Rectangular form only: Length __________ Width __________
Number of Stories _______
Area per Floor: Basement: _______ 1st _______ 2nd _______ 3rd _______ 4th _______

COST SCHEDULE - Please include breakdown if known; otherwise show total building cost.

	Cost
Site work	
Building enclosure	
HVAC	
Plumbing	
Electrical	
Special	
TOTAL	

3-144B

Appendix H

REVIEW OF SIGNIFICANT STUDIES

1. Albert F. Bemis, The Evolving House, 1937, a trilogy of which the third volume, Rational Design, is the most important.

PURPOSE: These studies sought to lay the groundwork for modular practice, covering design within a three-dimensional grid and the standardization of building materials.

MAJOR FINDINGS: While there was inadequate experience on which to base conclusions, there was widespread interest in prefabrication among housing sponsors. The diminished volume of actual construction at that time increased theoretical exploration of the potential of prefabrication.

CONCLUSIONS: The construction industry had much potential for increased efficiency and possible economics through modularization and mechanization.

2. Burnham Kelly, The Prefabrication of Houses, New York, 1951.

PURPOSE: To provide a history, state and prospects of prefabricated housing. Working data and detailed appendices make this volume, built on 14 years of the Bemis Foundation findings, achieve its purpose as the most comprehensive and valuable work on the subject at its publication.

MAJOR FINDINGS: While prefabrication became a movement in the 1930's and 1940's, it did not prove a panacea. Of 100 post-war prefabricators, only 42 lasted until 1951. A successful operation involved management, design, procurement, production and marketing. Also hoped for were inputs from behavioral studies, industrial associations, professional societies and government agencies.

CONCLUSIONS: Of the failing projects, most blamed financial problems—lack of adequate funds for research and development, for operating beyond initial stages, for establishing and training dealers.

3. Modular Coordination in Building, Asia, Europe and the Americas, United Nations, New York, 1966.

PURPOSE: To investigate the industrialization of building, particularly as it related to the standardization of house design and construction and to the unification of building codes and regulations.

MAJOR FINDINGS: The state of modular cooperation was reviewed in major world countries and regions, and found to be limited and divergent.

CONCLUSIONS: In summary recommendations, the importance of coordination was stressed to decrease building costs in both industrialized and developing countries, and this emphasized difficulties due to the use of metric and non-metric systems of measurement.

4. SCSD: the Project and the Schools, a report from Educational Facilities Laboratories, New York, 1967.

PURPOSE: To review the background, development and realization of the California school systems, from which many similar projects owe guidance and inspiration.

MAJOR FINDINGS: This profusely illustrated volume concisely conveys the philosophy of systems building as it pertained to the team planning, client aggregation, product manufacturer input, performance specification, and interfacing of components for school buildings. Mandatory reading.

CONCLUSIONS: No conclusions per se were drawn; considerable data are given, however, from which readers may deduce that the project was, on a whole, quite successful.

5. R. B. Guy and Associates, The State of the Art of Prefabrication in the Construction Industry, Columbus, Ohio, Battelle Memorial Institute, 1967.

PURPOSE: Done for the Building and Construction Trades Department of AFL-CIO, the research reviewed European and U. S. experience.

MAJOR FINDINGS: Increased use of prefabrication in the U. S. is likely, drawing on European systems, but more important, because of rising wages, land prices and other factors contributing to the higher cost of construction. Many constraints were noted, however, that would make the growth evolutionary, rather than revolutionary in nature.

CONCLUSIONS: Prefabrication is highly developed and will enlarge, despite constraints. Effects on labor will vary from distinct threats to opportunities, depending on the trade, and some trades will move indoors (from site to plant) for a larger portion of their work.

6. P. F. Patman team, Industrialized Building—A Comparative Analysis of European Experience, Department of Housing and Urban Development, Washington, 1968.

PURPOSE: To survey European industrialized building from economic, political, social and technological aspects, and to define optimum operations.

MAJOR FINDINGS: Although cost comparisons with conventional building are difficult (accounting is based on varying criteria), most countries plan to expand their operations. A trend is toward amalgamations, though effective limits to size of construction combines have been found, especially in some eastern European operations.

Cost inputs included design uniformity, market density and scale, state of the technology, size of production runs, size of capital investment, and organization of the work site.

CONCLUSIONS: Only with lowcost housing in economically developed urban areas, and with trained industrial and professional manpower, can industrial building be more efficient than conventional building.

Advantages are improved quality, reduced site labor and reduced construction time.

Benefits include a considerable infusion into the general economy, the manufacturing of machinery for prefabrication, increased vocational education, and the feedback from experience in production, transportation and erection, as well as a growing supranational trade.

Deficiencies are excessive standardization, the predominance of engineer over architect, and lagging building codes.

A fine annotated bibliography includes thumbnail reviews of 24 pertinent sources, most of which are not duplicated here because they deal with European work.

7. R. E. Platts, System Production of Housing in Northern Europe, National Research Council of Canada, Ottawa, 1969.

PURPOSE: To study European housing systems to determine patterns, processes and products that might be of value to Canadian work.

MAJOR FINDINGS: Management is probably more important than technical "elegance." The establishment of "land banks," the stabilizing of the market, the unifying of codes and block-financing are all important to successful system housing ventures.

CONCLUSIONS: The move to systems production appears to be concentrated in large firms which may offer a "total contract" package.

8. Kirkham-Michael, Study of Prefabricated and Pre-Engineered Buildings, Huntsville, Alabama, 1970.

PURPOSE: This study, done for the Department of the Army, set out to determine whether pre-engineered buildings (rather than conventionally built ones) should be contracted for two proposed sites.

MAJOR FINDINGS: For a dozen proposed buildings, two out of four bids from the responding steel companies came in under the bid for conventional construction.

CONCLUSIONS: Considering the limitations of weather and the need for visual continuity, the firm of Kirkham-Michael, Architects and Engineers, recommended that the pre-engineered building method be used.

9. McCue, Ewald, M. R. I., Creating the Human Environment, The University of Illinois Press, Urbana, 1970.

PURPOSE: The American Institute of Architects commissioned this study of the social and physical contexts of American life and its effects on the architectural profession.

MAJOR FINDINGS: Both severe restraints and unusual opportunities are in prospect for those involved in improving the environment. Studies including U. S. society, management and legal aspects of the U. S. building industry, and technology in the U. S. building industry found that current technology is adequate for the next 15 years. What is needed is federal stimulus, a national will and "social inventions" to provide adequate buildings, especially housing.

CONCLUSIONS: Professionalism is being redefined in light of profound change—political considerations over-riding engineering/economic considerations, and design management trends encompassing cybernetics, computerization, the behavioral sciences, and other important implications. The institute set down in this study guidelines for comprehensive evolution and growth in the latter part of the 20th Century.

10. Building Systems Information Clearinghouse Reports, beginning with their Newsletter (Volume I, Number I), Spring 1969, School Planning Laboratory, Stanford, California.

These publications are well written and illustrated, documenting progress of systems programs primarily in the school building field.

11. Digest of Seminars, Industrialized Building Exposition and Congress, Inc., Cahners Publishing Co., Inc. Chicago, 1970.

PURPOSE: To abstract the lectures and panels of the November 1970 Congress, held in Louisville.

MAJOR FINDINGS: 12,000 enrollees indicated the widespread interest in the possibilities for future industrialization within the industry. The diverse backgrounds of the program participants pointed out the varied interests involved in building design and construction, and while specific findings may be gleaned from individual presentations, no discernable patterns emerge in this digest.

CONCLUSIONS: No overall conclusions are attempted, but the publication is helpful if reference is made to the special subjects of marketing, production, government, management, transportation, design legal implications.

12. R. Ward, Jr., "Breakthrough?" AIA Journal, March 1971.

PURPOSE: The author chairs the American Institute of Architects' Housing Technology Subcommittee of the Operation Breakthrough Review Committee. He reviews the current state of the controversial Housing and Urban Development program Operation Breakthrough.

MAJOR FINDINGS: The mechanisms set in motion by Breakthrough are likely to have more far-reaching effect than any physical or product development. HUD efforts are to be lauded, but an apparent weakness is in the areas of research and development having to do with methodology, disciplines and similar issues inherent in building systems design and development.

CONCLUSIONS: Miniscule federal committment, as exemplified by meager funding, negates any significant progress. The program is a commendable beginning, but should be recognized as such.

APPENDIX I

STUDY PROCEDURES:
PLANNED CONSTRUCTION FOR NON-MILITARY
BUILDINGS SIMILAR IN FUNCTION TO
ARMY FACILITIES

3-147A

STUDY PROCEDURES

The first step in the estimation of the demand for non-military public buildings similar in function to military facilities was a subjective evaluation by a 10 man team of Architect-Engineers to ascertain the important congruencies and differences between asundry military and public building types. Armed with a resulting consensus, surveys were conducted to ascertain the magnitude of total non-military construction proximate to Fort Belvoir and Fort Knox. Finally, a mathematical model relating programmed non-military construction to community demographic features was developed to permit extrapolations to other military installation locations. A description of each study phase follows.

Functional Similarities between Military and Non-Military Facilities

1. Administrative buildings on Class I Army Installations tend to parallel office buildings generally located in sparsely populated, although nevertheless urbanized areas. For example, the bank building in a city of 50,000 would most likely be a low-rise structure of two to three stories, capable of accommodating approximately 150 people. Similarly, the headquarters for a Class I Installation will have this same magnitude of programmed occupancy.

Smaller administrative facilities on military installations are generally designed to accommodate specific administrative functions, i.e., finance vs. batillion headquarters, etc. The characteristics associated with this latter type of administrative facility are similar to the programmed occupancy parameters recognizable in neighborhood offices for professional civilians, such as lawyers, architects, etc.

2. Military storage facilities typically include a loading dock, railroad siding, large bay areas in which either bulky or lightweight equipment and supplies are stored. Essentially these facilities are repositories. Civilian warehouses directly parallel this type of military facility.

Furthermore, from an industrialized building viewpoint, wherein space allocations would not be constrained by basic structural design, the concept of the repository can be extended to include such civilian facilities as libraries where the same open bay area prevails. In both civilian and military storage facilities, one generally finds shelving which can accommodate the items being stored. In the final analysis, it is simply a matter of interpretation and frame of reference.

3. Military training facilities are basically classroom type buildings. It is with this building type that the compatibility between military and non-military facilities is closest. Certain functional differences do prevail, however, and will be considered in the following section.

4. Enlisted men's barracks tend to parallel non-military dormitory facilities, especially those occupied by juveniles. The traditional concept of the college dormitory cannot be applied to the enlisted men's barracks, except in the case of those newer barracks which have semi-private rooms. Both the military and non-military concept of dormitory/barracks facilities refer to the off-duty residence used to house those individuals undertaking a specific course of instruction, or having a predetermined tenure of stay.

5. Bachelor officer's quarters, while not quite the same as the typical apartment building, do tend to approach the concept of the civilian apartment hotel. The common denominator for each is a private room for the single individual with the programmed space for one or two additional individuals on irregular occasions. With reference to the efficiency or studio apartment in contrast to the multi-room apartment, residence hotels for elderly people, who frequently live alone, are virtually tantamount to bachelor officer's quarters.

6. Automotive/tank maintenance facilities found on Army installations are essentially garage-vehicle maintenance type buildings. Sheltered storage of vehicles is the congruent characteristic. On the surface, it would appear that very few public buildings would be of this type of programmed occupancy. However, not only do we find the vehicle maintenance facility being used by state highway departments at various field locations, we also recognize it in fire stations at the local government level.

Functional Differences Between Military and Non-Military Facilities

Having ascertained the congruent characteristics by building occupancy type in the previous section, an analysis was made of the functional differences recognizable for each building type Once again, we were primarily concerned with the nature of programmed occupancy.

1. The most obvious difference between a military administrative building and non-military office building is the volume of office equipment and other program support facilities. The typical civilian office building must accommodate computer equipment, conference rooms for each tenant or department, projection and visual display equipment, as well as individual telephone switchboards. Each of these is generally found in a separate building on an army installation. In other words, the programmed occupancy for administrative activities on an Army base is specialized, while it is comprehensive in a typical non-military office building.

2. With regard to repository buildings, military storage facilities are typicaly multi-purpose—having the ability to accommodate both equipment and supplies; non-military warehouses are usually constructed for a specific purpose, i.e., either hard goods or soft goods.

3. Military training facilities have historically disregarded the need for motivating occupants using the facilities. Conversely, motivation in the college classroom facility has always been recognized as essential. Civilians participating in an educational program are generally inspired for personal reasons and their classroom environment must be aesthetically conducive to the overall learning process. In contrast, training facilities on military installations are designed to enable the effective transfer of knowledge essential to the conduct of military affairs. Accordingly, the instruction environment does not play as important a role.

4. Functional differences between enlisted men's barracks and dormitory facilities are centered in the type of personal equipment required by the occupants. We may directly contrast rifle racks in barracks with book racks in dormitories. Similarly, tent poles and pegs, shelter halves, entrenching tools, etc. are replaced by pencils, erasers, and various types of paper in a college dormitory. The presence of an individual desk and study unit in a dormitory, and the absence of it in an enlisted men's barracks would be the most obvious functional difference between the two building types.

5. Bachelor officer's quarters are designed primarily for single men who are not expected to do an extensive amount of entertaining at home. However, apartment hotels must accommodate at least two individuals on a more or less regular basis. There must also be adequate kitchen facilities for the preparation of meals in the latter type. Bachelor officer's quarters and apartment hotels both require private baths.

6. Automotive maintenance facilities on Army installations are constructed to accommodate vehicles of different sizes. Public vehicle maintenance garages and fire stations are structured to accommodate a specific number of a particular type and size of vehicle. Furthermore, non-military vehicle maintenance facilities are used for both transient and permanent vehicle shelter, while most military facilities accommodate vehicles only during the course of maintenance per se.

The sum total of similar and dissimilar characteristics between military and non-military facilities yielded an awareness of the two frames of reference employed in discussing each type. Recognition of the fact that the frame of reference differs, rather than actual building characteristics lent support to the argument for mass purchasing of

Analysis and Projection of Total Demand for Non-Military Public Buildings

The $1.49 billion in non-military programmed construction for the six building types which was derived from a survey of 30 public agencies may be combined with the total military expenditures planned for the same building types to produce a composite dollar valume for 1971-1976. However, it is inadequate to merely sum two categories and expect to relaize the total demand for the six building types in the 4 geographical areas.

The total demand for non-military public buildings across the nation for 1971-1976 may be ascertained by deriving the proportion of military to non-military public construction prevailing in current dollars for 1970, applying the proportion to the known dollar value of military construction expected for 1971-1976, and adjusting the results to reflect wage rate and material cost trends over the five year period. This method, however, will produce a viable result only for the entire nation. Projection for any given geographical area would be biased upward by the inclusion of future military construction plans. This upward bias is predicated upon the assumption that the military would plan to utilize existing and future Army facilities in accordance with its programmed manpower requirements—a characteristic of military construction that is not prevalent in the non-military sector of public building construction at the local level.

Essentially, the demand for public buildings is a function of a recognized change in population for a given locale. Public-owned and occupied buildings, for the most part, are either schools, hospitals or administrative facilities. Any increase in the number of school-age individuals in an area is directly related to a need for an increase in school facilities. Similarly, the demand for administrative facilities and hospitals is dictated by an increase in the population and more specifically by an increase in the number of individuals employed in non-agricultural industries.

Any useful economic analysis considering population must also consider population density. This is especially necessary when a local area with a 50-mile radius about some focal point (Class I Army Installations in this study) is under investigation. For our objectives, population desnity may be realized, by comparing the levels of per capita public expenditures recognizable for the local area and for the state as a whole. The resulting ratio from such a comparison would be the desired desnity factor.
While the preceding population parameters provide a foundation for analysis of the demand for public buildings in a local area, any porjection of public building construction must, nevertheless, be expressed in terms of the number of buildings to be erected or the expected dollar value of programmed construction, preferably the latter. Accordingly, we need to consider prevailing construction trends for the national, state and local area in current (1970) collars. The availability of information in this respect is the obvious constraint of which the absence of construction magnitudes at the local level is the most formidable.

The basic assumption made in this analysis is that the ratio of private non-residential construction to public building construction at the national level approximates the ratio of these two magnitudes at the state level. This assumption is made in light of the fact that the only reliable construction data at the state level for 1970 is the reported number of permits issued for private non-residential construction.

We thus propose to project the demand for public buildings at the local level in 4 distinct steps:

I. Estimate the 1970 demand for public buildings at the state level by applying the ratio of public to private non-residential construction at the national level to the known volume of private non-residential construction at the state level. This may be expressed mathematically as follows:

$$\frac{PUBC}{PNRC} = \frac{PUBC_1}{PNRC_1} \qquad \text{(Eq. 4.1)}$$

Where: PUBC = Public Non-Military Building Construction
PNRC = Private Non-Residential Construction

Subscript 1 = State Level
(blank) = National Level

Solving for PUBC, which is the unknown quantity, Equation 4.1 may be written as:

$$PUBC_1 = PNRC_1 \frac{PUBC}{PNRC} \qquad \text{(Eq. 4.2)}$$

II. Estimate the 1970 demand for public buildings at the local level by applying the ratio of pre-school children + persons engaged in non-agricultural employment–state to local area, to the result from Step I. Mathematically this relationship is:

$$\frac{SPECPOP_2}{SPECPOP_1} = \frac{PUBC_2}{PUBC_1} \qquad \text{(Eq. 4.3)}$$

Where: SPECPOP = The Special Population Configuration of Pre-School Children + Persons Engaged in Non-Agricultural Employment

PUBC = Public Non-Military Building Construction

Subscript 1 = State Level
2 = Local Level (Standard Metropolitan Statistical Area–SMSA under investigation)

Solving for $PUBC_2$, which is the unknown quantity, Equation 4.3 may be written as:

$$PUBC_2 = PUBC_1 \frac{SPECPOP_2}{SPECPOP_1} \qquad \text{(Eq. 4.4)}$$

III. Refine the result from Step II—estimated demand for public building construction at the local level, by applying the ratio of per capita total public expenditures—state to local area, or:

$$D = PUBC_2 \quad \frac{\frac{T_2}{POP_2}}{\frac{T_1}{POP_1}} \qquad \text{(Eq. 4.5)}$$

Where: D = Adjusted Demand for Non-Military Public Building Construction in any Local Area for 1970

$PUBC_2$ = Unadjusted Demand for Non-Military Public Building Construction

POP = Total Population

T = Dollar Value of all Public Expenditures, General and Capital Outlay

Subscript 1 = State Level
2 = Local SMSA Level

IV. Multiply the result from Step III by five years (fiscal 1971-1976) to obtain the total projection of the demand for public buildings for the five year period.

Although this final step appears on the surface to be quite imprudent, the only alternative would be to consider the averages for the five year period 1966-1970 for each of the parameters in Steps I, II & III. In so doing, the dollar values for each year would have to be adjusted to account for increases in labor wage rates and material prices. The absence of reliable adjustment data at the local level (especially with respect to per capita public expenditures) precludes the consideration of this alternative.

The implication consistent throughout the above procedural steps is that the proportions derived for 1970 will, on the average, approximate the proportions over the five year period, 1971-1976. If the local economy is characterized by inflation in the first two-three years (i.e., 1971-1973) and has recognizable recessionary trends in the latter years (i.e., 1973-1976), then the analysis is biased toward the earlier years. If the opposite of these conditions should come to pass, the projections would be biased toward the latter years.

In light of these considerations, we have proceeded to project the demand for non-military public buildings for 1971-1976 in the four geographical areas in which the survey was taken.

Tables 1 and 2 present the source data for each required parameter, by local area. The estimated value of public building construction for 1970, column 3-Table 1 was derived using Equation 4.2 above. The number of preschool children for the states and for the selected areas was obtained from the 1970 Census Reports (1).* Non-agricultural employment data was compiled from Employment and Earnings (2), published by the Bureau of Labor Statistics. The private non-residential construction data, as well as certain miscellaneous construction data was obtained from Construction Review (3) a United States Department of Commerce publication.

Compiling data for the locales under investigation necessitated consideration of both the cities and counties within the 50 mile effective radius of the individual Class I Army Installations. While the Columbus, Georgia Standard Metropolitan Statistical Area (SMSA) conforms to the prescribed area about Fort Benning, Georgia and the Louisville, Kentucky SMSA approximates the effective area about Fort Knox, Kentucky, certain additions were required in considering the Fort Belvoir, Virginia and the Fort Ord, California areas. For the latter, the Monterey-Salinas SMSA and the San Jose SMSA were combined inasmuch as the effective area consumes major portions of both SMSA jurisdictions. For Fort Belvoir, Virginia, it was not only necessary to take the Washington, D.C. SMSA (which includes portions of Virginia and Maryland), but to take the volumes in that SMSA twice—in order to realize accurate proportions. The Washington D. C. SMSA, in other words, represents ½ of the total area consumed by the 50 mile radius about Fort Belvoir, Virginia.

Furthermore, as the Fort Belvoir, Virginia area comprises two states (Virginia and Maryland) and the District of Columbia, the private non-residential construction data for each was the private non-residential construction data for each was summed and taken as a whole. The volume of private non-residential construction for the States of Georgia, Kentucky and California were taken singularly in the analysis.

The fact that the volume of Federal construction in the Fort Belvoir area is considerably more than the other three areas also required an adjustment. Seventy-five percent of the 1970 total federal building construction for administration, educational and institutional facilities was added to the total estimated volume of public building construction for the States of Virginia and Maryland and for the District of Columbia per Equation 4.1.

*Parenthetic numerals indicate references.

Table 5

SUMMARY OF CONSTRUCTION VOLUMES AND 1970 POPULATION STATISTICS USED IN PROJECTING THE DEMAND FOR NON-MILITARY PUBLIC BUILDINGS IN THE VICINITY OF TWO CLASS I U. S. ARMY INSTALLATIONS 1971 - 1976

	Pre-School Children + No. of Persons in Non-Agricultural Employment: 1970 Census	Private Non-Residential Construction: 1970 (Millions of Dollars)		Estimated Value of Public Building Construction: 1970 (Millions of Dollars)
Fort Belvoir, Va.				
State of Virginia	1,823,205	$339.9	)	
State of Maryland	1,610,873	296.6	)	$622.0
Dist. of Columbia	737,235	82.2*	)	
U. S. Government	-----	-----		267.6
Wash. D. C. SMSA	2,740,902**	-----		---
Fort Knox, Kentucky				
State of Kentucky	1,151,579	127.4		110.3
Louisville SMSA	383,923	---		---

SOURCE: U. S. Dept. of Commerce and U. S. Dept. of Labor (see test)

NOTES: *75 percent of 1970 total for Administrative, Educational, Institutional Building Construction for Federal ownership and occupancy.

**Twice the actual value (see test).

Table 6

PUBLIC EXPENDITURES, PREVAILING POPULATION AND PER CAPITA ANALYSIS 1966-67 FISCAL YEAR IN THE VICINITY OF TWO CLASS I U. S. ARMY INSTALLATIONS

	All Expenditures by Public Sector 1966-67 Fiscal Year (Thousands of Dollars)	Population During 1966-67 Fiscal Year		Per Capita Public Expenditures 1966-67
Fort Belvoir, Va.				
State of Virginia	$1,699,552	4,464,700	)	
State of Maryland	1,689,856	3,610,600	)	$439.94
Dist. of Columbia	519,171	809,005	)	
Wash. D. C. SMSA	2,111,800	4,970,456		424.87
Fort Knox, Kentucky				
State of Kentucky	1,278,100	3,181,100		267.29
Louisville, SMSA	209,447	783,600		401.78

SOURCE: 1967 Census of Governments, U. S. Dept. of Commerce

NOTE: *Twice the actual values (see text).

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